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Department of Economics and Development

Social Change and Agricultural Development Paradigm: The Case of E-Wallet Utilisation Amongst Farmers in Southwestern Nigeria

Ph.D. Thesis

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I hereby declare that I have done this thesis entitled Social change and agricultural development paradigm: The case of e-wallet utilisation amongst farmers in the southwestern part of Nigeria independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to citation rules of the FTA.

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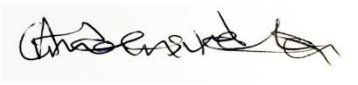

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Abstract

The e-wallet system is a mobile phone-based platform connecting farmers directly with inputs subsidy provided by the Nigerian government to boost farm productivity. Many countries promote food security through agricultural policies to boost agricultural productivity without looking at the effect of such policies on sustainability. Despite introducing the e-wallet system to distribute subsidised inputs among Nigerian smallholders, the utilisation remains relatively low. Thus, this research investigates the communication channels and adoption barriers that affect the use of e-wallets and the effect of agricultural policies and land ownership on the adoption of Sustainable Agricultural Practices in Nigeria. The study was conducted in Nigeria between August and November 2018 with a sample population of 288 farmers (156 e-wallet users and 132 non-users, selected using a purposive multi-stage sampling technique). The binary logistic regression results show that a higher frequency of receiving information from extension agents, the Federal Ministry of Agricultural staff, participation in farmers' groups, and attendance at farmers' field schools increased the probability of the adoption of e-wallet. Low levels of awareness, technical problems with mobile phones, and distance to the input redemption centres were identified as major obstacles to e-wallet adoption. Optimisation of the provision of extension services, helping farmers with phone navigation, establishing more redemption centres, and improving the phone network would be the first steps needed to increase adoption. The result also revealed that agricultural programs affected the adoption of Sustainable Agricultural Practices. Farmers who participated in e-wallets were more likely to adopt fertiliser trees and animal manure and were less likely to adopt planting basins than non-users. This study provides practical implications for fostering sustainability through effective agricultural policies and land ownership to facilitate adoption rates of Sustainable Agricultural Practices.

Keywords: Adoption barriers; agricultural research and extension; farmer participation; land ownership; policies; Sustainable Agricultural Practices.

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List of the abbreviations used in the thesis

e-wallet	Electronic Wallet
FGN	Federal Government of Nigeria
FMARD	Federal Ministry of Agric & Rural Development
FFS	Farmers Field School
GESS	Growth Enhance Support Scheme
GSM	Global System for Mobile Communications
HH	Household Head
IT	Information Technology
NGN	Nigerian Naira
NBS	National Bureau of Statistics
NPK	Nitrogen Phosphorus and Potassium
SAP	Sustainable Agricultural Practices
SMS	Short Message Service
TV	Television

1. Introduction

One of the Sustainable Development Goals is to achieve food security and agricultural policies' main objective, particularly in developing countries. Food security may be improved by intensifying agricultural production using an appropriate combination of inputs. In Nigeria, the productivity of staple food production remains low, owing to a drop in farming households' access to input packages. This is mainly attributable to a drop in assistance for farmers to access agricultural inputs like seeds and fertilisers due to the government's earlier failures to implement agricultural reforms (Baipethi and Jacobs 2009). The introduction of some innovative or targeted input subsidies will boost the utilisation of input packages. These inputs should be provided at a reasonable cost, accessible, and free from any form of bottlenecks. It is important to note that smallholder farmers in most of Sub-Saharan Africa rely on informal ways to receive inputs from the open market at a high cost (Smale et al. 2009). For example, some seed access channels are on-farm seed saving, farmer-to-farmer exchange, and unregulated sales. In order to increase smallholder farmers' access to inputs, there is a need for intervention that removes bottlenecks preventing smallholder farmers from benefitting from government input subsidies (Baipethi and Jacobs 2009).

The e-wallet policy of the Federal Government of Nigeria, investigated in this study, aims at food security by encouraging agricultural intensification through the provision of fertilisers and seeds. As many smallholder farmers do not take advantage of using input subsidies provided by the e-wallet program, we investigated which factors affect the use and which barriers prevent the farmers from participating. Based on this knowledge, the e-wallet policy could be adjusted to reach more farmers. It has to be taken into account that providing input support often encourages farmers to enhance their output by intensifying or expanding the area under cultivation. When input policies are not properly designed it could jeopardise agricultural sustainability and the environment (Kivimaa & Mickwitz 2006; Runhaar 2016). Furthermore, studies show that policy focus was given to intensification over the years without much concern for the ecological effects (Barnes et al. 2016; Mutyasira et al. 2018). For example, input subsidies on non-sustainable farming practices, including intensive tillage

and the extensive application of chemical inputs (e.g., pesticides, herbicides, and mineral fertilisers), have resulted in severe degradation and erosion of soils in Moldova (Boincean et al. 2016). To prevent those environmental damages, adopting Sustainable Agricultural Practices (SAP) is recommended. SAP represents "a resource-saving agricultural crop production approach that aims to produce acceptable profitability while maintaining high and consistent output levels while safeguarding the environment" (FAO 2015). Furthermore, adopting SAP can improve agriculture sustainability by reducing agricultural input and less waste generation (Mwalupaso 2019). To conclude, agricultural policies face the challenge of finding a balance between boosting food production and reducing its environmental consequences (Mensah 2015; Runhaar 2016). To understand the environmental effects of agricultural policies in more detail, this study investigated if different policies used in the study area affected the use of SAP by farmers.

Excursus:

E-wallet system in the context of inefficiencies of input distributions in the Nigerian agricultural sector in the past

In Nigeria, agricultural input subsidy occupies a central role in the policy tools of the government (Umar et al. 2015). According to Takeshima and Liverpool-Tasie (2013), fertiliser subsidy alone constituted nearly 68 % of government agricultural expenditure in the recent past. Input subsidies support farmers in reducing their production costs and improving their profit margin. Over the years, the Nigerian government has been spending considerably on subsidised farm inputs (especially fertiliser). The direct costs of fertiliser subsidy per metric ton (MT) under the Market Stabilization Scheme (MSS) was US $ 27 (₦ 10,261) in 2001 and has geometrically increased to US $ 144 (₦ 55,000) in 2015. Banful et al. (2010) found that the primary constraint to inputs used by smallholder farmers in Nigeria in the area of seeds is the absence of the inputs at the time that it is needed and the high cost of such inputs in the open market, which could have occurred due to the diversion of the subsidised seed inputs provided by the government.

However, for over 40 years, black marketers held Nigerian farmers and authorities in the agricultural sector to ransom. Black-market agents are the powerful middlemen in the industry who allegedly ensured that the government's critical farming inputs never got to farmers (NBS

2016). They controlled the fertiliser distribution system and hijacked subsidised farm inputs meant for farmers by diverting the farm inputs to be sold in the open market. At the same time, official records show that subsidised farm inputs have been delivered to the farmers. The corrupt politicians in connivance with some government officials benefitted greatly from this practice, which limited the accessibility of the farmers in getting the inputs needed to increase their production (Abiodun et al. 2017). The consequence of these corrupt actions, such as diverting the subsidised inputs into the market and selling to the farmers at high prices, short-changed smallholder farmers. The introduction of the Electronic Wallet (e-wallet) platform and creating a database of farmers in 2012 was to reverse the trend through building a new transparent government system devoid of political influences.

Before introducing the e-wallet, the Nigerian input subsidies delivery system was plagued by issues of unfair distribution among farmers. Agricultural subsidies totalled US$ 5.8 billion US dollars between 1980 and 2010, with an estimated US$ 5.2 billion US dollars lost due to corruption (Henry-Ukota et al. 2012). In Nigeria's previous system, the government with the influence of politicians played a significant role in distributing subsidised inputs (Adesina 2013). Middlemen, mostly government officials, were involved in the distribution, and subsidised inputs were frequently not delivered to the targeted smallholder farmers (Ayoola & Ayoola 2016).

For instance, apart from controlling the Federal Government's fertiliser distribution system for about four decades, the black marketers whose activities verged on economic sabotage also denied farmers access to other subsidised inputs such as disease-resistant, high-yield rice seeds and palm oil seedlings. Instead, the inputs, which would have seen farmers' output rising and contributing to food security, job, and wealth creation, were sold in the open market at high prices or smuggled into neighbouring West African countries. These continue to reduce the potential of the agricultural sector.

Specifically, the black marketers were hurting the continent's efforts at empowering its youth population by making agriculture an attractive start-up sector for them. The former Minister of Agriculture and Rural Development and African Development Bank (AfDB) President, Dr. Akinwumi Adesina, did not mince words when he said: "We must turn rural areas from zones of economic misery to zones of economic prosperity. This requires agricultural innovations and transforming agriculture into a sector for creating wealth. We must make agriculture a cool choice

for young people. The future millionaires and billionaires of Africa will come initially from agriculture." (Adesina 2017). This was at the 2017 G7 Summit in Taormina, Italy. At the event, Adesina expanded on this vision, saying: "The future of Africa's youth does not lie in migration to Europe, nor should it be "at the bottom of the Mediterranean." He proposed that an agribusiness-driven economy could be one of the economic reasons Africa's youth choose to remain on the continent.

Adesina's (2017) vision was backed by innovation and creativity in modernising agriculture, getting the youth engaged in the sector, and changing their perception to allow them to see agriculture as a viable and profitable business. Through the e-wallet, Adesina (2012) pioneered a new way for the Nigerian government to deliver subsidised farm inputs, such as fertiliser and seeds, to local farmers through private agro-dealers. The farmers, in turn, redeem these subsidised inputs from the agro-dealers using e-vouchers, which they can access through their mobile phones. The database, coupled with the e-wallet, allowed Nigerian farmers to receive inputs such as fertiliser to high-yield rice seeds and palm oil seedlings directly from the government.

2. Literature review

2.1 Understanding the e-wallet mechanism under Growth Enhancement Support Scheme (GESS)

Electronic wallets (e-wallets) are an integral part of the electronic payment system. The term "e-wallet" refers to a digital wallet that allows individuals to link their debit or credit cards to a digital wallet to make any transactions (Digital Wallet 2019). Apart from debit or credit cards, electronic cards enable consumers to store their physical card information and bank account numbers to perform specific actions towards payment (Ray 2017). Payments done using an e-wallet have proved to be more convenient and faster than conventional banking systems as it saves time and money (Blockchains 2018). The cellular-based payment system is widely used for transactions, and payments are made using mobile applications because consumers consider this method beneficial (Gokilavani et al. 2018). Payment using an e-wallet provides ease and speed and gives consumers a sense of comfort and a sense of security in transactions elsewhere and at any time (Liébana-Cabanillas et al. 2014). The use of an e-wallet offers small-scale transactions which are very easy to operate (Punwatkar et al. 2018). The rapid development of information technology facilitates by providing its distinct characteristics of the payment system. Due to the increasing number of e-payment systems, consumers are shifting from cash-based to cashless, yet converting to a non-cash economy is complex. Existing cash-based trading practices are still firmly compacted (Yaokumah et al. 2017).

The Growth Enhancement Support Scheme (GESS) is a constituent of the Agricultural Transformation Agenda (ATA) introduced in Nigeria in 2011 as a central platform for farmers to connect with the government to receive pertinent information predominantly in agricultural novelties, technology, and input delivery through electronic wallets (e-wallet). It is an innovative approach to fertiliser subsidy and other inputs administration through an electronic system that ensures that only registered farmers benefit from the scheme. The innovation was believed to change the mentality of Nigerians toward agricultural activities

by increasing access to inputs which are some of the challenges farmers face. It is expected that the scheme will boost food production, the income of farmers, and the value accorded to locally produced agricultural products. Under the GESS e-wallet scheme, the government's role shifted from direct procurement and distribution of fertiliser to facilitation of procurement, ensuring good quality fertiliser gets to the farmer, and promoting the private-sector fertiliser value chain (Adesina 2012; Uduji et al. 2018a; Uduji et al. 2019a). In this process, the Federal Government of Nigeria (FGN) and state governments each contribute 25 % of the fertiliser cost, resulting in a 50 % subsidy offered directly to smallholder farmers (IFDC 2013). The GESS e-wallet scheme appeared to be more efficient and transparent in subsidy delivery to smallholder farmers. For example, the FGN spent ₦ 30 billion (US$ 180 million) in 2011 to reach 800,000 smallholders with inputs, whereas it spent N5 billion (US$ 30 million) in 2012 to reach 1.2 million smallholders (Grossman and Tarazi, 2014; Uduji and Okolo-Obasi, 2018b). Tashikalma and Chinda (2018) highlight the successes and challenges of the scheme's implementation process across the country. The study reviewed scholarly articles and other secondary data from government sources on the scheme. Findings from the study revealed that the scheme could deliver subsidised agricultural inputs to small-scale farmers with relative ease and at a reasonable rate, boosting farm output.

The mobile phone (electronic wallet system) is at the heart of technology applications under the GESS. The e-wallet technology ensures that a Nigerian farmer receives farm input subsidy support from the FGN through accredited agro-dealers; provides vital agro-information alerts; is available to the agricultural extension system, and facilitates micro-lending and insurance schemes (Olomola 2015). The quick acceptance of the e-wallet programme has sparked a lot of conjecture and anticipation about its impact on the country's economic progress (Adesina 2013; Grossman & Tarazi 2014; Wossen et al. 2017; Adenagen et al. 2018; Uduji & Okolo-Obasi 2018b). However, an emerging body of research shows that the reduction in communication costs associated with the e-wallet programme has intangible economic benefits, including the improvement of agricultural as well as producer and consumer welfare in specific circumstances and areas (Adebo 2014; Fadairo et al. 2015; Nwalieji et al. 2015; Trini et al. 2014). It is important to note that while the term "e-wallet" is broad to include electronic(e)-cards, online/internet payments and mobile phones which

form part of the e-wallet are exclusively used in this research to represent e-wallet because of the consistency of the mobile phone with the government intervention programme. In Nigeria, the input distribution process was created to assist farmers in gaining direct access to inputs, overcoming the corruption difficulties along with the farm inputs distribution, financial inclusion of the farmers, and effective communication between the farmers and the governments. Also, for an agro-input dealer to participate in the program, they must own a cell phone with a registered SIM card, understand the process of using an e-wallet, and attend training programs on sensitisation of the innovation and development designed for the project. In addition, the agro-dealers must contribute positively to the program's success based on the following expectations: honest business ethics, guide against fraud, identify a location for the business transaction, provide storage facilities, and be available at the appropriate time to attend to farmers' needs (Fadairo et al. 2015). Other stakeholders in the scheme are the helpline personnel and redemption supervisors. Each state's Agricultural Development Project (ADP) supplied the helpline staff, and about 3-to 5 helpline staff are assigned to each of the Local Government Areas of all the geopolitical zones in Nigeria. The helpline staff and supervisors connect to the farmers daily to attend to their needs. In addition, the redemption supervisor helps verify the farmer's identity and the code in the text message received by the farmer, i.e., comparing them with the names and codes listed in the programme register, which the supervisor received from the programme implementing body (Alabi and Oshobugie 2020).

The subsidised farm inputs are delivered directly to farmers through their phone notification on the closest location of the redemption centre, where they can access it at a subsidised rate. When inputs are available for redemption, the farmer receives an SMS with a code, and the farmer pays 50 % of the cost of the inputs provided after they were validated at the redemption centre. The agro dealer then uses the validated vouchers to redeem the government's 50 % contribution (Olomola 2015). A farmer is eligible for the e-wallet voucher if they meet specific criteria: to be a smallholder farmer with less than 5 hectares of farmland, over 18 years old, registered with the government agencies such as the Federal Ministry of Agriculture and Rural Development (FMARD), have a cell phone with a registered SIM card

and at least 60 nairas ($0.16) credit (Adebo 2014). The way the e-wallet works can be seen in Figure 1. Regardless of farm size, all farmers received the same amount of inputs.

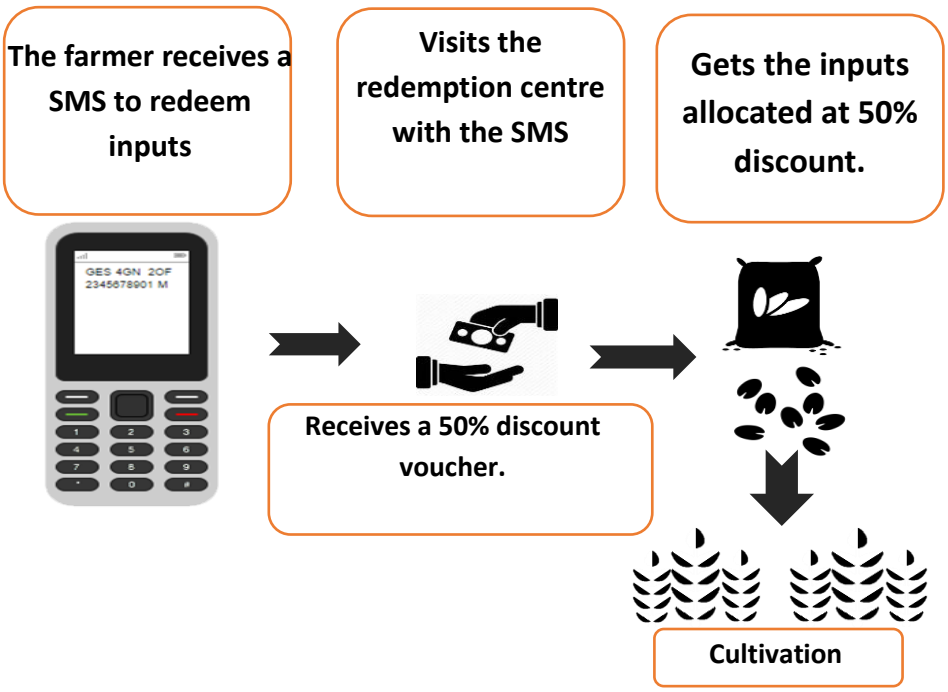

Figure 1. The process of redeeming inputs by farmers through the e-wallet scheme. Source: Author, 2020

The project is expected to provide direct linkage between the farmers and the government. Its implementation is also under the assumption that it enables the government to disseminate valuable information on the access to loans, grants, and good management practices to the farmers, thus ensuring farmers' progress (Ezeh 2013). In addition, the system does not push out the private sector from an agricultural input supply (NAN 2012). The e-wallet was introduced in May 2012 as a pilot project in 36 states and the Federal Capital territory. It is a Federal Government initiative to enhance the Agricultural Transformation Agenda (ATA). According to the Federal Ministry of Agriculture and Rural Development (2015), about 3.914 million farmers registered for the scheme in 2012. The number increased to 9.5 million farmers in 2013 and 10.5 million farmers in 2014. Under the scheme, the quantity of fertiliser distributed to farmers increased from 120,900 metric tones in 2012 to 466,600 metric tones in 2013, rising phenomenally to 748,800 metric tones in 2014 with inputs distributed in three

seasonal production cycles to farmers. Despite these unprecedented funds and participation accomplishments, many smallholder farmers did not participate in the support programme inputs. For example, the Nigerian government hoped to reach 20 million farmers, but only about 10.5 million signed up for the e-wallet scheme (FMARD 2014).

2.2 Sustainable Agricultural Practices (SAP) in Nigeria

Nigeria is a country that faces many challenges in the agricultural sector. The sector is under severe pressure to meet the food needs of a growing population. This has led to a heavy burden on agricultural production systems, resulting in some negative environmental setbacks, for example, erosion, deforestation, soil degradation, and biodiversity loss (Goodfray et al. 2010). Soil degradation is a huge global issue whose consequences are felt most acutely in poorer countries, where large segments of the people rely on the soil for their livelihoods. Soil deterioration in Sub-Saharan Africa (SSA) has been related to hunger and poverty due to decreased crop output (Sanchez 2002; Sanchez & Swaminathan 2005; Tully et al. 2015). Due to damaging environmental human activities, pH, soil organic carbon (SOC), and accessible P have been steadily declining in Nigeria for many years, resulting in scarce land resources for farming (Lal 1998 & Shehu et al. 2015). Many smallholder farmers in Nigeria were not active adopters of SAP due to their meager resources and poor engagement in adopting agricultural innovation over the ineffective traditional methods used (Titus & Adefisayo 2012). D'Souza and Mishra (2018) noted that land fragmentation, lack of technical know-how, and sustenance of agricultural programs posed challenges to adopting SAP in Sub-Saharan Africa, including southwest Nigeria.

Substantial attention was paid to SAP's positive contribution to the sustainability of the ecosystem. For example, cover cropping, crop rotation, and minimal tillage have environmental benefits such as reducing carbon through sequestration, reducing nutrient leaching and erosion, and promoting insect pollination (Bergtold et al. 2015; Poeplau & Don 2015). Similarly, crop diversification promotes biodiversity and economic diversification that protect farmers against climate and market risk (Carlisle 2016; Darkwah et al. 2019). SAP support available agricultural land fertility to sustain productivity (Christiaensen &

Demery 2007). Losing agricultural fertility of the land due to some environmental and human factors could be a massive loss to the farmer (Adelaja and George 2019). The need for improved fertility of the soil leading to an increase in crop yield, food security, effective land management, and income of household influences the adoption of SAP by farmers (Nkomoki et al. 2018).

Crop diversification, fertiliser trees, mulching, animal manure, cover crop, and planting basin are Nigeria's most frequently used sustainable farming strategies:

1. Crop diversification: This practice improves food security by allowing farmers to grow surplus items for market sale and earn more money to meet other demands connected to household well-being (Choudhary et al. 2019). Crop diversification is the practice of growing various crops on the same piece of land. Cereals, legumes, and tubers are the most common combinations. As these crops are impacted differently, the chances of full crop failure during shocks are minimised (Jahanshiri et al. 2020).
2. Fertiliser trees: The place of fertiliser tree, which can also be referred to as bio-fertiliser, uses leaf droppings or dead plants where nitrogen is drawn from the air and transferred to the soil. In sustainable farming, organic fertiliser has been identified as an alternative to chemical fertiliser for increasing soil fertility and crop yield. As eco-friendly and cost-effective inputs for farmers, these possible organic fertilisers would play a major role in soil production and sustainability and protect the environment (Khosro and Yousef 2012).
3. Mulching: The technique of adding undecomposed plant materials to the soil beneath the plants, such as straw, hay, or processor waste. Mulching materials are most commonly used in orchards under trees kept in permanent sod.
4. Animal manure: refers to the solid, semisolid, and liquid waste products produced by animals raised to produce meat, milk, eggs, and other agricultural goods for human use. Alabi and Ajayi (2018) affirmed that agricultural extension agents play a significant role in disseminating information on animal manure management, which

is part of the agricultural programs introduced to smallholder farmers in southwestern Nigeria.

5. Cover crop: Land is a significant barrier to farming in Nigeria, resulting in SAP implementation such as cover cropping for smallholder farmers (Adeyemo et al. 2017). A cover crop is a crop that grows near the ground and provides soil protection, seeding protection, and soil enhancement in between periods of conventional cropping.
6. Planting basin: In West Africa, notably Nigeria, the strategy is widely utilised to lessen the risk of crop loss owing to irregular rainfall (Otim et al. 2015). Planting basins are holes dug in the farm with a specific diameter. Typically made during the dry season, the crops are planted in the basins after the rains arrive (Mazvimavi and Twomlow 2009).

2.3 Land ownership system in Nigeria

A land ownership system includes how farmland is acquired, the usage, the size acquired, and the exploitation of certain parts of the land. The system of land ownership in Nigeria can be communal, which can be obtained in cases of leasehold, family inheritance, their progenitor's acquisition and gift. The government of Nigeria introduced the land Use Act of 1978, which outlines the regulated procedures for land transactions leading to people's right of ownership over a piece of land. The Act gives the government (the States) the authority to issue Certificates of Occupancy to persons who want to buy land under their jurisdiction (Mabogunje 2010; Adeniyi 2011). This Land Use Act provides legal support for acquiring any land in Nigeria that was not previously under the Federal government's jurisdiction or a state governor. In addition, the Act empowers the governor of a state to award land in all urban areas to persons or organisations residing in the state for agricultural, commercial, residential, and other purposes, similar to the authority granted to local government authorities in non-urban areas. The land use act was inspired by the need for all Nigerians to have unhindered access to land; to prevent speculative purchases of communal land; regulate and simplify the management and ownership of land; to enhance land availability to

governments at all levels for purposes of development, and develop a system of government administration of rights with a focus on promoting land tenure security (Yahaya 2019).

Bamire and Fabiyi (2002) revealed that farmers in the southwestern part of Nigeria cultivated farmland for about 13 years before allowing it to go fallow for an average of 2 years. It implies that the soil nutrient might be drastically depleted, thereby reducing the productivity of the land (yield). In addition, farmers who do not have a permanent right to a farm, for example, women or tenants, are usually discouraged and prevented from planting trees (Fenske 2010; Nyaga et al. 2015; Majing et al. 2017; Mahmood & Zubair 2020). Bamire and Fabiyi (2001) further noted that farmers in southwest Nigeria who use their land through borrowing, gifting, leasing, and sharing, compared to purchasing and inheritance, are typically less secure in embarking on long-term agricultural activities, which leads to limitations in adopting some SAPs.

One of the most identified limitations to adopting SAP is land tenure insecurity, related to the period of ownership a farmer has over a piece of farmland (Fouladbash and Currie 2015). Land ownership positively affects SAPs adoption (Nkomoki et al. 2018; Adusumilli and Wang 2019). Empirical evidence shows that the farmers who have secured land ownership and rights implemented more climate-smart agriculture practices (Mazhar et al. 2021). On the contrary, Tesfu (2011) argued that land tenure was not a precondition to farmers' decisions on soil conservation practices use but noted that the farmers' income, education, and labour determined the adoption of SAP. Previous studies investigated the effect of land ownership on the adoption of SAP in Nigeria (Oladele et al. 2011).

3. Aims of the Thesis

The Nigerian government implemented the e-wallet scheme to reduce corruption in the input subsidisation policy and thus increase its effectiveness. The inputs are directly delivered to the smallholder farmers through a mobile phone technology where farmers receive vouchers to redeem inputs instantly from redemption centres. However, for different reasons that have not been very well-investigated, the acceptance and adoption rates of the smallholder farmers' e-wallet system were lower than expected. The Nigerian government had aimed to reach 20 million farmers with the e-wallet innovation by 2014, but only approximately 10.5 million farmers were registered (FMARD 2014). Hence, the study seeks to fill the gap and investigate the factors that affect the adoption of the e-wallet by smallholder farmers. Primarily, the study is interested in understanding how the information used by farmers affects the adoption of e-wallets. This understanding can help the government provide targeted information to increase the adoption level of the e-wallet. To better understand the adoption/non-adoption, this study looked into the factors that influenced smallholder farmers' use of the e-wallet program. Previous research on the adoption of e-wallet programs in Nigeria identified technical barriers such as a poor telephone network, long distances to redemption centres, a lack of funding, and bureaucratic verification processes (Demenongu and Yahaya 2017; Abiodun 2016; FESPAN 2012; Uduji et al. 2018; Jamaluddin 2013; Meera et al. 2004; Nwalieji et al. 2015; Nwaobiala & Ubor 2016) However, the barriers in their complexity involving perceived ease of use have not been investigated.

A considerable amount of attention was paid to factors that influence farmers' adoption of SAP. For example, several studies investigated the effect of socioeconomic, institutional, and agro-ecological factors that influence the adoption of SAP (Carlisle 2016; Nkomoki et al. 2018; Pilarova et al. 2018; Boppa et al. 2019). Prior literature considers the role of agricultural policies, including e-wallets, in encouraging SAP implementation. Farmland policies have been stressed as one approach to stimulate the adoption of pro-environmental agricultural practices to enhance farm and environment quality (Cao 2020). In addition, agriculture policies promote farmers' behaviour change and integration through institutional

innovations to support positive, sustainable agriculture development to attain farm productivity (Liu et al. 2021). Furthermore, agricultural policies implemented in Nigeria in the last decade, such as the e-wallet programme and Fadama, have brought increased production and improvement in the livelihood and standard of living of the rural population in the southwestern part of Nigeria, thereby stimulating great potential for adoption of SAP in the region (Apata and Saliu 2015; Famakinwa et al. 2017; Agbarevo and Ukagba 2018). However, past research has paid little attention to the impact of agricultural policies/programs on farmer adoption of SAP. As a result, the purpose of this research is to look into the impact of policy programmes on SAP adoption.

3.1 Main aim of the thesis

The study's primary objective is to examine the factors that affect the adoption of e-wallets among smallholder farmers in Nigeria. Furthermore, the study examines the effect of governmental agricultural programmes and land ownership on adopting Sustainable Agricultural Practices (SAP).

3.2 Specific objectives of the thesis

The specific objectives of the study are:

i) Analyse the influence of information sources used on the adoption of e-wallets among smallholder farmers.
ii) Examine the technical barriers to the adoption of the e-wallet among smallholder farmers.
iii) Analyse the influences of agricultural policy programmes such as e-wallets, Fadama, and land ownership on adopting Sustainable Agricultural Practices.

3.3 Research questions

The following questions were addressed in this study:

(i) Which information sources and channels used by farmers influence their adoption of e-wallet?
(ii) What are the technical barriers to adopting the e-wallet among smallholder farmers?
(iii) Do government policy programmes such as e-wallets, Fadama, and land ownership influence the adoption of Sustainable Agricultural Practices?

3.4 Hypotheses

Based on the literature reference review, the study seeks to test the following hypotheses:

(i) *T*he information sources and channels used by farmers influence their adoption of e-wallet.
(ii) The perceived technical barriers to adopting the e-wallet prevented farmers from using the e-wallet.
(iii) Government policy programmes such as e-wallet and Fadama affects the adoption of Sustainable Agricultural Practices.

4. Theoretical Background and Conceptual Framework

4.1 Theoretical background

4.1.1. Communication channels in the context of diffusion of technological innovations

The diffusion of innovations, such as the e-wallet program among farmers, is primarily dependent on the willingness of the farmers and the reliability of the system to meet the needs of the farmers though the technology was made so simple that it does not require formal education (Rogers 2003; Van 2009; Sumane et al. 2018; Thu & Thidar 2019). Agricultural information can be obtained through both formal and informal channels ((Extension contact, Cooperative society, Farmers groups, Farmer Field School and Fadama program). Formal sources are radio, television, the internet, governmental and non-governmental extension services, and seminars/workshops. At the same time, peer farmers, family members, and friends are examples of informal sources. The theory of diffusion and adoption of technology reported that the diffusion and adoption of technology indicated a positive effect on social capital (Rogers 2003), valid in an agricultural setting. Membership in farmer groups and cooperatives, for example, enables farmers to receive information from other farmers (Liverpool-Tasie 2014). Farmers' meetings in rural areas, on the other hand, are an essential tool for disseminating information to farmers (Agbarevo & Ukagha 2018).

The investigation of adoption barriers was based on previous studies, highlighting how complexity, availability, and affordability can affect technology adoption (Rogers 2003). Previous research on the adoption of e-wallet programs in Nigeria identified technical barriers such as a poor telephone network, long distances to redemption centres, a lack of funding, and bureaucratic verification processes (Demenongu and Yahaya 2017; Abiodun 2016; FESPAN 2012; Uduji et al. 2018; Jamaluddin 2013; Meera et al. 2004; Nwalieji et al. 2015; Nwaobiala and Ubor 2016) However, the barriers in their complexity involving perceived ease of use have rarely been investigated.

According to Rogers (2003), diffusion is the process by which an innovation is communicated through specific channels over time among the member of a social system (Figure 3) and by which alteration occurs in the structure and function of a social system as a kind of social change. Therefore, diffusion is a critical process for the practical use of innovation and reinvention. In other words, diffusion plays a pivotal role in helping the adopters fully take advantage of innovation and modify that innovation. Thus, comprehending the significant issues in the diffusion process is essential for successful technology transfer.

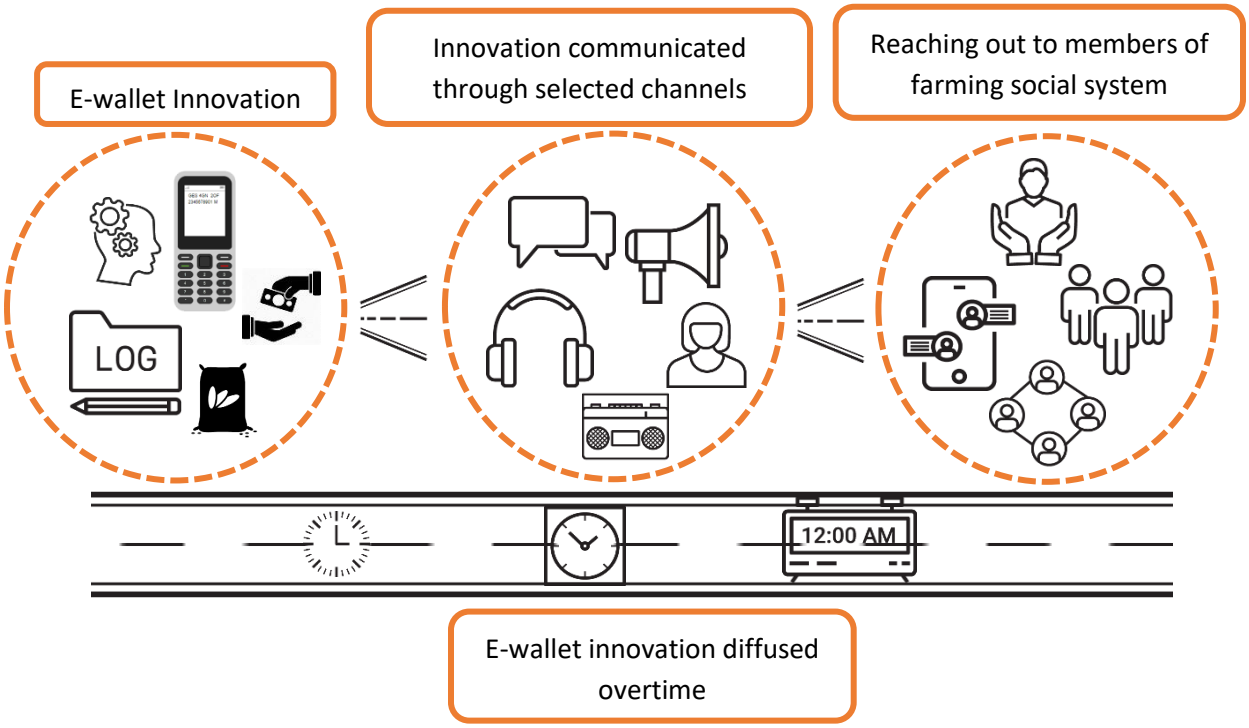

Figure 2. Process of diffusing e-wallet innovation to farmers. Source: Author, based on Rogers (2003).

It is good to understand that the adoption of an innovation like e-wallet is characterised by a decision-making process that goes through the mind of a farmer through an information-gathering and information-processing activity via the various communication channels earlier mentioned and in Figure 3, in which a farmer is motivated by engaging them in their social system with the aim of reducing ambiguity regarding the benefits and drawbacks of an innovation, which is done over time through the various contacts and engagements with the

farmer. Due to some possible barriers and limitations, we can have an adoption outcome, which means "to accept the e-wallet innovation as an appropriate innovation that will meet their farm input needs," or, in contrast, a rejection which means the farmers are classified as non-adopters.

Diffusion consists of four key elements: innovation, communication channels, time, and a social system (Rogers 2003). The diffusion issues can be broken down based on the various components in diffusion. According to Rogers (2003), innovations have five common characteristics that help explain the adoption rates: relative advantage, compatibility, complexity, trialability, and observability. He argues that the greater comparative advantage, compatibility, trialability, and observability and the less complex the perceptions of innovation are, the faster the adoption rate. Change agents need to use this implication to speed up the diffusion rate and make the potential adopters recognise the need for change.
According to Petrović et al. (2004), rural communities are part of a global society and share its circumstances. However, they are particular social organisms in many ways, especially when it comes to changes in the countryside and agriculture. Therefore, the process of introduction (adoption) and spreading (diffusion) of innovation, knowledge, and technology - which is usually at the centre of social change in rural communities – is a complex and contradictory process (Simin 2014).

4.1.2. Conceptual framework on the adoption of e-wallet and Sustainable Agricultural Practices (SAP)

Figure 3 illustrates the numerous constituting factors (e.g., Information Sources/Communication Channels, Household Head, Farm, and Institutional Characteristics) that may influence whether or not a smallholder farmer in Nigeria adopts the e-wallet scheme. The consequences of several identified barriers were further investigated to see their impact on farmer adoption of e-wallets. Figure 4 illustrates the relationship of the agricultural policy programmes with Household Head, Household, Farm, and Institutional Characteristics on influencing a farmer to adopt SAP like Crop diversification, fertiliser trees, mulching, animal manure, cover crop and planting basin.

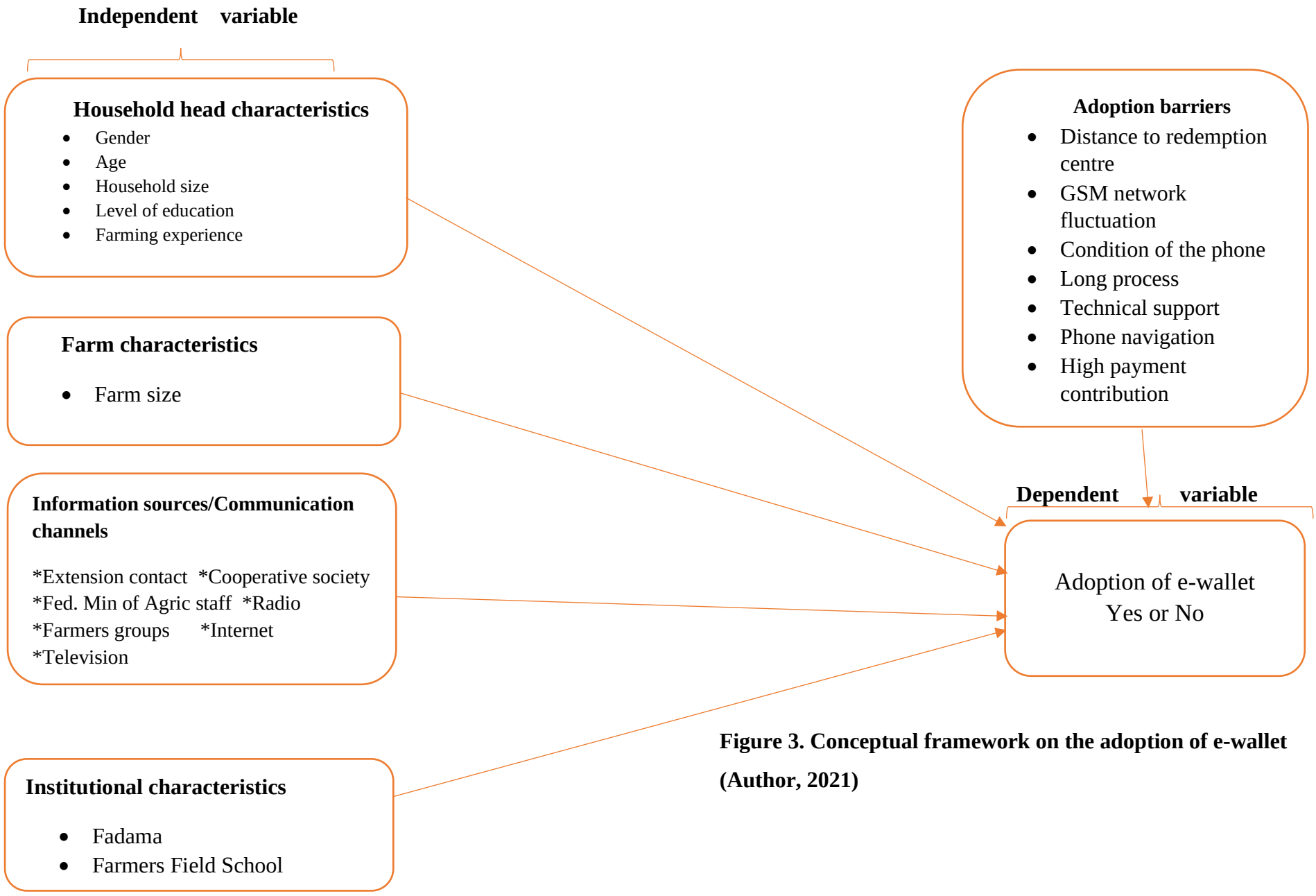

Figure 3. Conceptual framework on the adoption of e-wallet (Author, 2021)

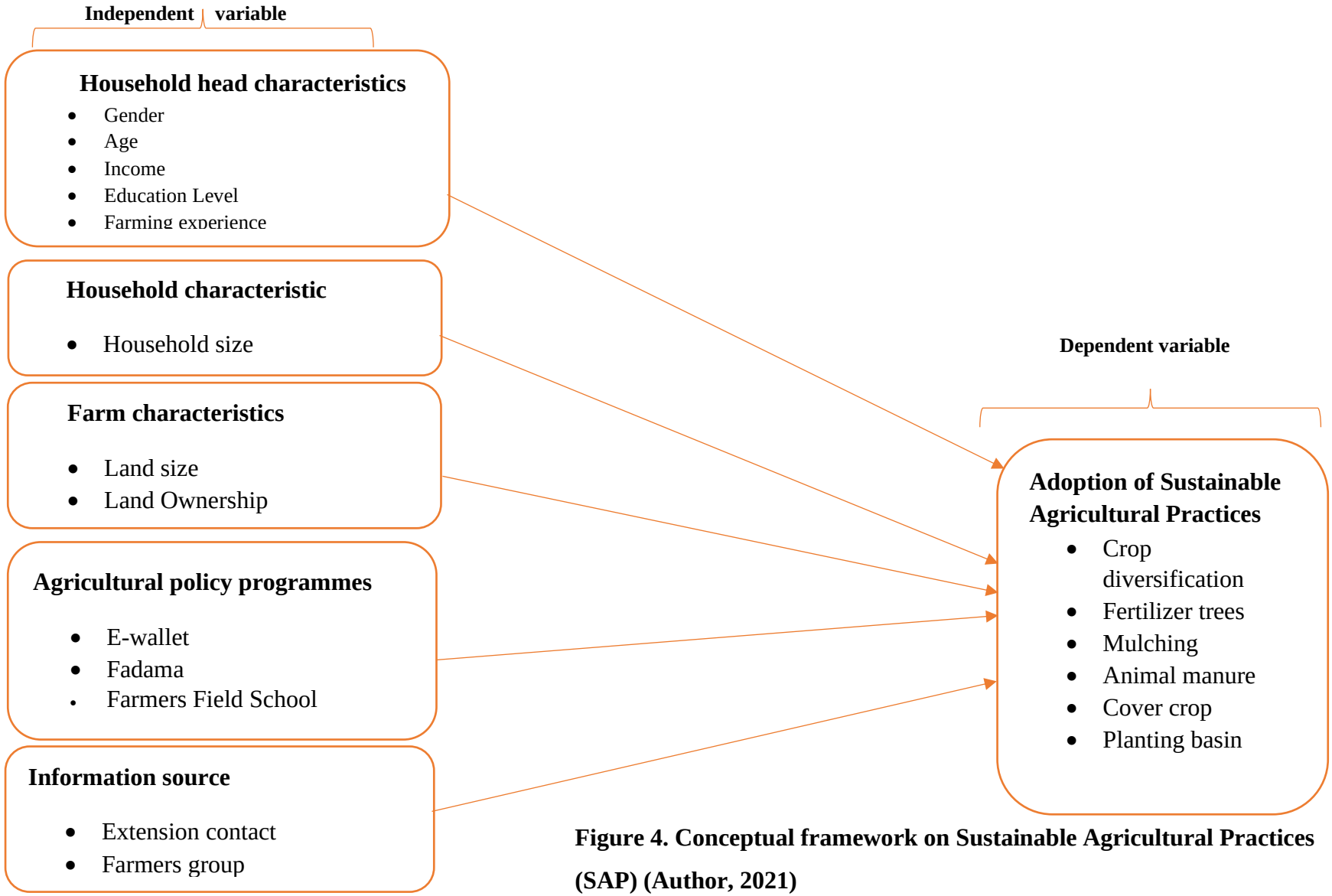

Figure 4. Conceptual framework on Sustainable Agricultural Practices (SAP) (Author, 2021)

The understanding of the various variable that are linked to influencing a farmer in adopting the e-wallet scheme is very key and important to this research.

Household head characteristics

Gender

There is a need to understand the gender involvement in the e-wallet since the e-wallet scheme had gender-specific policies and services geared towards rural women in Nigeria's agricultural and rural developmental sectors (Takeshima and Nkonya 2014). This is based on the belief that Africa's growth and development agenda will be successful only if the continent can tap into all of its resources and talents and if women can fully participate in economic, social, and political life, which will necessitate increased efforts to eliminate discrimination and promote equal rights. In rural areas, gender differences in agriculture are primarily defined by unequal access to modern agricultural inputs (Uduji & Okolo-Obasi 2018b).

Age

Farmers' age has some perceived effects on their involvement in the e-wallet scheme, influencing whether they accept or reject changes (Uduji et al. 2019). This affirms the findings of Adebo (2014) and Godson-Ibeji et al. (2016) that most of the farmers that benefitted from the e-wallet scheme are still young with an open mind to accept innovation due to their age and are expected to be active in keying into the e-wallet approach and thus make effective utilisation of the scheme to enhance their productivity.

Household size

The size of a farmer's family has some perceived effects on their technological adoption practices like e-wallet based, as the larger the household size, the more influence they possibly have on the household choice, and e-wallet focus on smallholder farmers where their household size is the strength of their farm activities (Menghistu et al. 2020). Melesse (2018)

found that the size of a farmer's household affects the adoption of agricultural technologies in Ethiopia.

Level of education

The level of education is one of the most important criteria that influences farming household adoption decisions (Tura et al. 2010). According to Wozniak (1997), education improves farmers' ability to collect, process, and utilise technology-related information.

Farming experience

The amount of years a farmer has been in the field exposes them to more information regarding government policies and innovation, which influences their choice of any new technology. According to Amurtiya et al. (2018), agricultural experience in Nigeria affects the adoption and satisfaction with e-wallets.

Farm characteristics

Farm size

Smallholder farmers with a farm size of less than 5 hectares were targeted by the e-wallet scheme designed to help small-scale farmers improve their productivity (Adebo 2014). This demonstrates that the Nigerian government introduced the e-wallet as a policy to support the agricultural production of smallholder farmers who primarily have a farm size of less than 5 hectares. This is expected to help smallholder farmers improve their situation by ensuring timely access to fertiliser, seeds, and other critical agricultural inputs.

Land ownership

Access to a farm land plays a significant role for a farmer to be able to access an e-wallet as this is part of the considerations required to be eligible, and the type of ownership, whether owned or leased, will also affect the adoption of an innovation (Mgbenka et al. 2016)

Information sources/communication channels

Extension contacts

Farmers' engagement in the e-wallet initiative is assumed to relate to their contact with extension agents. The present study is in accordance with Aker (2011)'s assertion that enhanced seed could reach farmers in developing nations faster if agricultural information via mobile communication is supplemented by interaction with extension personnel in rural regions. Contact with extension agents appears to be a favourable factor for e-wallet participation. Extension agents work to change farmers' behaviour toward new technologies and information, which is often attributed to a lack of knowledge or understanding of farmers' perspectives and needs on the part of information providers. Therefore, increasing the number of extension agents also boosts farmers' behaviour toward new technologies and information.

Cooperative society

The credibility among cooperative members is significant in improving the distribution of inputs which is a good platform for extension agents to engage farmers about e-wallets (Nwaobiala and Ubor 2016). This result is consistent with Faturoti et al. (2008), who found that cooperative membership is significant in using agricultural technologies.

The staff of the Federal Ministry of Agriculture

With the new reforms and transparency introduced in the agricultural ministry, selected staff members of the Federal Ministry of agriculture in Nigeria played a significant role in conceptualising and implementing the e-wallet scheme which was also based on their competence. They were involved in reaching out to farmers about the importance of their enrolment in the e-wallet and provided necessary technical support in the registration process. They also managed the farmers registered in collaboration with the private sector services providers and ensured that the e-wallet initiative worked.

Radio

The importance of radio in agricultural information dissemination cannot be overemphasised by looking at Nigeria's infrastructure challenges, especially in rural communities. The challenge of having access to a power supply has made the radio the best alternative in passing across innovations like the e-wallet to farmers because of the availability of radio sets powered by batteries. Most mobile phones have a radio built-in them. Agricultural programs are more frequent on the radio as they are less complex to produce. It is a faster means of reaching out to farmers about the e-wallet scheme and allows farmers to call in to ask more questions on a live radio program. Adebo (2014) investigated the efficiency of e-wallet practice in delivering grassroots agricultural services in Kwara State, Nigeria, and proposed that radio broadcasts of e-wallet system programs in several Nigerian local languages be enhanced.

Farmers´ group

Farmers' groups are usually non-financial based associations divided into small cluster groups in various communities where extension agents easily reach out to the farmers during group meetings. Farmers who join farmer groups are more likely to be sensitive to innovations or community interventions, which may influence their attitude toward adopting new technologies as they broadly rely on the collective decisions of the group. The collective group structure also makes information passage easier (Adesina et al. 2000).

Internet

Despite the challenges with internet connectivity issues, internet access cannot be brushed aside. It has an essential role in opening access to information on agricultural innovations like e-wallets. However, it could be limited to the infrastructural challenges in Nigeria. The more time farmers spend on the internet on a daily basis, the more positive their perceptions of the internet's remote services, high efficiency in information dissemination, information reliability, convenience, personalised interaction, and other features are, and the more likely they are to adopt new agricultural technology promotion methods (Rana et al. 2016).

Television

One of the most successful mediums for agricultural technology transfer among farmers is television. It has been hailed as one of the essential communication tools now available. The unique blend of sight, sound, and motion are responsible for most of its educational success. The use of a combination of audio and visual cues has been shown to alter human behaviour and, as a result, increase farmer learning (Carpenter 1983; Ani and Baba 2009).

Institutional characteristics

Fadama

Farmers participating in the Fadama program are made aware of the potential benefits of adopting new agricultural technology; the Fadama program has accelerated the adoption process of new agricultural innovations by farmers. This results from extension personnel using appropriate communication techniques in communicating with farmers. There is a strong emphasis on how previously established technologies such as the Fadama program can greatly influence farmers to participate in e-wallets. The emphasis on implementing proven technologies is based on the reality that enhanced farm technology availability, affordability, applicability, and adoption are at the core of the numerous avenues for increasing agricultural output (Chukwuji 2013).

Farmer Field School (FFS)

The FFS is founded on the principle of discovery-based learning. In the process of technology development, validation, distribution, diffusion, adoption, and finally, the anticipated long-term influence of on-farm practices among smallholder farmers, which is related to the focus of the e-wallet, there is equal collaboration. Learning through doing is emphasised in the FFS approach. The learning takes place in the field and is usually intended to last for the entire growing/cropping season (Moumeni-Helali & Ahmadpour 2013). This allows farmers to fully engage in the deployment of all aspects of the technology, from access to planting help, which is the e-wallet scheme's primary goal, until harvesting. Farmers can observe and reflect on the technologies' benefits and drawbacks as a part of the learning process, creating a

promising avenue for making informed decisions about whether or not to use them (Asiabaka et al. 2003).

5. Methods

5.1 Study area

The research was carried out in three states in southwestern Nigeria: Ondo, Ekiti, and Oyo (Figure 2). southwestern Nigeria is bounded on the south by the Atlantic Ocean, North by Kwara and Kogi states, east by Edo and Delta states, and west by the Republic of Benin. Geopolitically, the southwest zone is divided into six states: Lagos, Ogun, Osun, Oyo, Ondo, and Ekiti. Southwest Nigeria covers an area of approximately 114,271 square kilometres, or around 12% of the total land mass in Nigeria, with typical rainforest vegetation across the region. The climate in southwestern Nigeria is predominantly humid, with annual rainfall ranging from 1500 mm to 3000 mm. Maximum temperatures on the southwestern coast and in southern cities range between 33.0 and 36.0°C (NiMeT 2012). The southwest zone is divided into six states: Lagos, Ogun, Osun, Oyo, Ondo, and Ekiti State. These states are situated mainly in the tropical rainforest zone with swamp forests in the coastal regions of Lagos, Ogun, and Ondo states. The area also covers the derived Savannah in the extreme North of this region, including Oyo, Osun, and Ekiti states. The Ondo State was created on the 3rd of Feb, 1976, presently with 18 Local Government Areas, a land area of 15,500 square kilometres with about 3,440,000 people. The area lies between latitudes 5^0 45^1 and 8^0 15^1 North of the Equator and longitude 4^0 3^1 and 6^0 0^1 East of the Greenwich meridian, with a total land area of 77,818 square kilometres in 2014 (NBS 2015). The average annual rainfall of Ondo State has low variability. It is bimodality distributed: rainy season (April to October) and dry season (November to March); temperature ranges from 21°C-28°C with high humidity. The dry season brings harmattan dust; cold, dry winds from the northern deserts blow into the southern region. Hence, crop and livestock production is not constrained by the amount and distribution of rainfall.

The vegetation pattern across the Ondo State varies by climate and rainfall. The Ondo State has three major vegetation zones: mangrove/freshwater, tropical rainforest, and derived savanna. All the vegetations are rich in agricultural soils that support the cultivation of

diverse crops for both humans and livestock. Although some parts of the Ondo State are relatively urbanised, most of the population still lives in rural areas. The people of this area are mainly agricultural with structure, engaged in farming (both crops and livestock production), hunting, fishing, lumbering, and handicraft. Other occupations include civil service and trading.

The Osun State is one of the six states comprising southwestern Nigeria. It covered an area of appropriately 14,875 square kilometres and is located between longitudes 5^0 4' to East 4 0 to West and latitudes 8^0 l5' to the North and 6° 5^1 to the South. It is bounded by Ogun, Kwara, Oyo, Ondo, and the Ekiti States in the South, North, West, and East. The state lies within the tropical rainforest. Traditionally, the people engage in agriculture and produce sufficient food and cash crops for domestic consumption as input for agro-allied industries and export. Other occupations of the people include cloth-weaving, mat-weaving, dying, soap making, and wood carving, among many others.

The Ekiti State is a State in the southwestern region of Nigeria. The State is within the tropics. It was created on October 1st, 1996 and comprised 16 Local Government Areas (LGAs). The Ekiti State occupies a land mass of approximately 6,6028 square kilometres and a population of 2,432,321 (NPC 2006). It is situated between 4^0 45^1 and 5^0 45^1 East of the Greenwich meridian, and latitude 7^0 15^1 and 8^0 5^1 North of the Equator. It comprises sixteen (16) Local Government Areas, with Ado – Ekiti as the State capital. The Ekiti State is bounded in the North by Kwara and the Kogi States, in the South by Ondo – State, in the west by Osun State, and in the East by the Ondo – State. The Ekiti State has a mean annual rainfall of about 1400 mm and a mean annual temperature of about 27°C. Its vegetation ranges from rain forest in the South to guinea savannah in the North, with soil essentially rich in organic minerals, making the State a significant producer of tree and food crops.

Moreover, the state has two main seasons, i.e., the rainy and dry seasons. The occupation of the people is farming, producing food crops like yam, maise, cassava, rice, cocoyam, etc., and some cash crops such as cocoa, kola nut, cashew, and oil palm, with a reasonable

percentage of them engaging in other forms of occupation such as trading, weaving, and handcraft, etc.

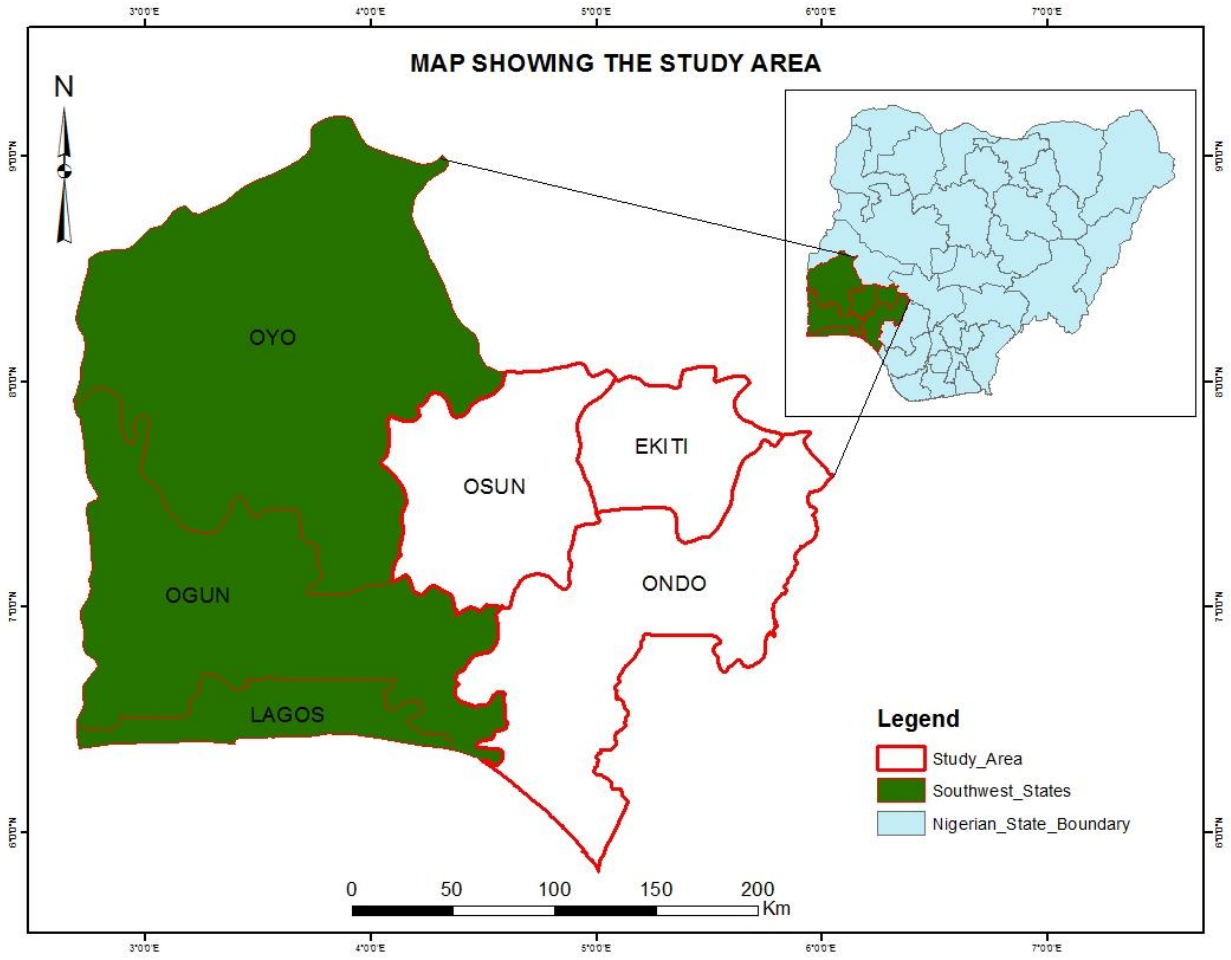

Figure 5. Study Area (Source: Author 2018)

5.2 Sampling Procedure

A multi-stage sampling technique was used for the study. The first stage involved selecting three of six states in southwestern Nigeria, namely Ekiti, Ondo, and Osun. The second stage entailed selecting two Local Government Areas (LGAs) from each state on purpose (Ekiti state - Moba and Gbonyin; Ondo state - Akure South and Akure North; Osun state - Ife East and Ife South). The third stage involved a deliberate selection of two communities from each

LGA (Ondo state- Adofure and Ijoka communities in Akure south local government area; Araromi and Eleyewo communities in Akure north local government area; Ekiti state - Ira and Osun communities in Moba local government area; Ilumoba and Ijan communities in Gbonyin local government area; Osun state - Ilode and Yekemi communities in Ife east local government area; Mefoworade and Aaye communities in Ife south local government area) based on the communities' high agricultural activity. The final step involved a random selection of thirteen farmers from each community who participated and eleven farmers who did not participate in the e-wallet scheme. Thus, three states, six local government areas (LGAs), 12 communities, and 288 farmers (156 e-wallet users and 132 non-users) were selected for the study.

5.3 Data collection

A self-administered structured questionnaire was utilised in eliciting information from the respondents. The data was collected across the three states in Nigeria between August and November 2018 through face-to-face interaction with the farmers on their farms and sometimes during farmers' meetings. English, Yoruba, and pidgin language were used to communicate with the farmers. The researcher collected the data with trained agricultural researchers in Ekiti State University, Ado Ekiti, as well as the state and Nigeria's Federal Ministries of Agriculture staff. The survey questionnaire included household head, household and farm characteristics, information sources and channels used, and barriers to participating in the e-wallet scheme. Pre-testing was conducted with 30 respondents to verify the internal consistency of the research instrument in Ekiti State, Nigeria. The questionnaire was adapted according to the feedback provided by the farmers. The validity of the constructed questionnaires was assessed by two experts who were well acquainted with research instrumentation and familiar with the Nigerian smallholder agricultural practitioners and the input subsidy system.

5.4 Validity of research instrument

Content validity of the research instrument was carried out with the help of experts in the field to ascertain the content appropriateness of data collection. Validity refers to "the accuracy of the inferences, interpretations, or actions made based on test scores" (Johnson & Christensen 2014). The validity of constructed questionnaires was assessed by a panel of experts who consisted of two individuals who were well acquainted with research instrumentation, those familiar with the Nigeria smallholder agricultural practitioners and the input subsidy programme. This was done by studying the construct, examining the questionnaire content, and deciding whether the test content adequately represents the construct. The content validity assessment was done by Prof. Grace Modupe Adebo of Ekiti State University, Ado-Ekiti, Nigeria, and Dr. Bankole Falade, Stellenbosch University, South Africa, because of their knowledge of data collection, survey instrumentation and related financial policies by the government.

5.5 Data analytical techniques

Descriptive and inferential statistics were employed to analyse the data collected using Stata (Version 13). Descriptives in the form of mean, mode, and standard deviation were used to group and summarise farmers' characteristics, household characteristics, farm characteristics, institutional characteristics, and Sustainable Agricultural Practices.

Models for the adoption of agricultural input policies

Inferential statistics used were the binary logistic regression model and T-test.

A binary logistic regression model was used in achieving objective 1 (Analyse the influence of information sources and channels used by farmers on the adoption of e-wallet.); the model is presented below:

$$\text{logit}(p)=\alpha+\beta_1 X_1+ \beta_2 X_2+\dots \beta_{14} X_{14}+e \quad (1)$$

Where:

Y= Dependent binary variable 0/1

$$p = P[Y = 1] \qquad logit(p) = \ln(\frac{p}{1-p})$$

Logit is also called log-odds

α= Regression constant

β_1- β_{14}= Regression coefficient

X_1= Gender, X_2= Age, X_3= Household size, X_4= Level of education, X_5= Farm size under cultivation, X_6= Farming experience, X_7= Extension contact, X_8= Staff of Federal Ministry of Agriculture, X_9= Cooperative society, X_{10}= Television, X_{11}= Radio, X_{12}= Internet, X_{13}= Farmers groups, X_{14}= Farmer Field School, e= Error term

Dependent variable

The dependent variable Y measured farmers' adoption of the e-wallet program and was binary (Adopted=1, Otherwise= 0).

Independent variables

The vector of independent variables (**X**) was selected based on previous studies identifying the information sources used by farmers. Control variables were chosen according to studies (presented in Table 1), which investigated factors related to adopting innovations, and the variables isolated included farmer and farm characteristics.

E-wallet adoption barriers

The T-test was used to determine the difference between the e-wallet perceived adoption barriers reported by the e-wallet adopters and non-adopters (Objective 2- to examine the barriers to the adoption of the e-wallet by farmers).

The Perceived barriers included the following problems

- Distance to the redemption centre – There are instances where the distance to the redemption centre is far from the farmers' location.
- High payment contribution by the farmers – Due to the long distance to the redemption centre, the farmers complained that the cost of transport to the centre with the 50% subsidised payment is sometimes more than what they will get the inputs from a nearby market and also considering the static number of inputs given to every farmer irrespective of their farm size.
- GSM network instability – The fluctuation in access to the GSM network is a significant issue preventing farmers from having access to agricultural information.
- Condition of the phone – Faulty phones and the type of phones used could limit farmers' access to information.
- The long process of registration/data and input redemption. The bureaucracy involved in the registration process and redemption of inputs is of great concern.
- Technical support – The regular access to technical support by farmers is a major booster to the sustained use of the e-wallet.
- Inability to use the phone properly – Due to the age and exposure of some farmers, they still have challenges in knowing how to access and respond to messages from the redemption centre.
- Low level of awareness – The low level of knowledge on information about the e-wallet will affect the acceptance of the e-wallet scheme.

Table 1. Independent variables of the logistic model for the adoption of e-wallet measurement and selection

Variable	Description	Literature
Age	Actual age. This was later categorised into different age groups below 30, 31-50, 50-70, and above 70.	Chibwana et al. (2012) revealed that lower age has a positive significant influence on the likelihood of adopting and participating in a subsidised fertiliser coupons program in Malawi.
Gender	Male -1, Female – 2	Donkor et al. (2016) reported that female-headed households are more likely to participate in the Ghanaian agricultural subsidy program.
Educational level	No formal education=1, Educated= 2.	Uduji and Okolo-Obasi (2018) stated that the educational level of the farmer significantly affected the adoption of e-wallets in Nigeria.
Farming experience	An actual number of years of farming experience and measured using an interval scale.	Amurtiya et al. (2018) concluded that the level of adoption and satisfaction with e-wallets was influenced by farming experience in Nigeria.

Farm size	Actual farm size measured in hectares.	Adebo (2014) revealed that farmers with more than five hectares did not adopt the e-wallet scheme due to Nigeria's small number of inputs.
Household size	The number of people in the respondent's family was measured using an interval scale.	Melesse (2018) confirmed that farmers' household size influenced the adoption of agricultural technologies in Ethiopia.
Information sources	The frequency of information usage was classified using the Likert scale of very often=5, often=4, sometimes=3, rarely=2, and not at all= 1 as an ordinal variable where the mean was determined to know the information source frequently used. The information sources include farmers' groups, extension contact, television, cooperative society, Federal Ministry of Agricultural staff, radio, and the internet.	Ragasa and Mazunda (2018) reported the significant influence of extension contact on participation and access to agricultural input subsidies in Malawi.
Previous agricultural programmes	This was measured as a nominal variable where farmers identified the programs they participated in (Fadama, Farmer's field school)	Coker (2014) agreed with the importance of the World Bank assisting the Fadama program in aligning with the e-wallet scheme.

Models for the adoption of SAP

Logistic regression models were used to address objective 3 (Analyse the influence of agricultural policy programmes and land ownership on the adoption of Sustainable Agricultural Practices), which is to find the determinants for the adoption of SAP among small-scale farmers as used in the literature (Usman et al. 2016; Ndiritu et al. 2014). The formula used is presented below:

$\text{logit}(p)=\alpha+\beta 1X1+\beta 2X2+\ldots\ \beta 13X13+e$ (2)

Where:

Y= Dependent variable (Sustainable Agricultural Practices, 1= adopter, 0= non-adopter)

$$p = P[Y = 1]$$

$$logit(p) = \ln(\frac{p}{1-p})$$

α= Regression constant, $\beta 1$- $\beta 13$= Regression coefficient, X1= Gender (1= male, 2= female), X2= Age (<30, 30-50, 51-70 and > 70 years), X3= Level of education (1= no formal education, 2= adult education, 3= primary school, 4= tertiary education), X4= Farming experience (years), X5= Income (Naira/month), X6= E-wallet (1= adopter, 0= non adopter), X7= Household size (number of people), X8= Land size under cultivation (ha), X9= Land owners percentage, X10= Extension contact (how frequent in farming season 1-5), X11= Participation in Fadama programme (yes =1, no =0), X12= Farmers' Field School (Participation in Farmers' Field School (yes =1, no =0), X13= Farmers' groups (Participation in farmer group, yes =1, no =0), e= Error term. The models were tested for multi-collinearity using correlation, Variance Inflation Factor (VIF), and tolerance coefficient. The results indicated that the variables were independent as the VIF coefficient fell within the acceptance

level of 5 (Akinwande et al. 2015). The Durbin- Wu-Hausman did not show any effect of potential endogeneity.

Considered sustainable practices

The dependent variables in the six regression models are binary (adopted/non-adopted) and based on six SAPs adopted by smallholder farmers in Nigeria.

(i) Crop diversification is defined as cultivating various crops on a given farm area. This is viewed as an ecological practice that reduces risks and uncertainties in food production (Chavas & Falco 2012). Additionally, Nguyen et al. (2017) indicate that crop diversification can serve as a strategy in terms of weather shocks in different environments. Crop diversification provides benefits of nutritional diversity from various crops (Lin 2011).

(ii) The practice of planting fertiliser trees is attributed to an increasing supply of nutrients for crop production through nitrogen fixation in the soils and improvement of soil fertility (Coulibaly et al. 2017). Further, Akinnifesi et al. (2010) argued that agroforestry ensures crop yields and delivers food security to households.

(iii) Mulching and water conservation practice. This involves the retention of crop residues on the field to improve water holding capacity, better aeration, and improve soil fertility. The residues include maize straws, rice straws, and leguminous leaves, among others (Gathala et al. 2013).

(iv) Animal manures are a source of nutrients and improve soil fertility. The amount of animal manure is influenced by livestock ownership. The farmers, in most cases, accumulate the manure from their livestock, and in other cases, the manure is obtained from neighbours or other farmers owning more livestock.

(v) Cover crops and green manures are an important SAP in sustainable land use in fixing nitrogen in soils. The cover crops are ploughed back into the soils, thus enriching soil nutrients through decomposing residues (Fageria et al. 2005). Furthermore, cover crops and green manures are used to suppress weed growth. Some common species include leguminous cover crops: sun hemp (*Crotalaria*

spp.), pigeon pea (*Cajanus cajan*), jack bean (*Canavalia ensiformis*), and velvet bean (*Mucuna pruriens*), and non-leguminous cover crops such as sunflower (*Helianthus annuus*) (Pratt & Wingenbach 2016).

(vi) Planting basins are usually prepared in the dry season, and with the onset of the rains, the crops are planted in the basins (Mazvimavi & Twomlow 2009). The method is commonly used in West Africa, including Nigeria, to reduce the risk of crop failure due to erratic rainfall (Otim et al. 2015).

Independent variables of the logistic model for the adoption of SAP

A thorough literature review was conducted to explore the effect of agricultural policies, land ownership, and control variables in the models previously found to affect the adoption of SAPs. Agricultural policies affected the adoption in some studies (Agbarevo & Ukagha 2018; Lawal et al. 2010). Several studies (Nkomoki et al. 2018; Nyaga et al. 2015; Majing et al. 2017; Mahmood & Zubair 2020) identified land ownership affecting SAP adoption. Household size, farmer training, and knowledge were identified as factors influencing compost manure adoption among smallholder farmers (Mustafa-Msukwa et al. 2011; Pampuro et al. 2018). Farmers' years of farming experience, frequency of visits by the extension agents, and social status significantly determined the adoption of SAP in southwest Nigeria (Olawuyi & Mushunje 2019). Mishra et al. (2018) noted that factors affecting the adoption of sustainable agriculture practices among Kentucky farmers were the type of cultivated crop, the farmer's age, education, and knowledge about SAPs. Lesch and Wachenheim (2014) identified the barriers to adopting conservative agricultural practices, including a reduction of program base acreage, lower-income, reduced flexibility in land use, poor market dynamics, and negative relationship between landlord and tenant.

6. Results

6.1 Descriptive statistics

Farm head and farms‘ characteristics

Table 2 shows that the farmers were predominantly males with 83.0% and had a low population of females (17 %). The data revealed that more than half of the respondents (60.8%) in the study area were between the age range of 31 – 50 years, 34.4% were between the age range of 51 – 70 years, while those less than 31 years and above 70 years share 3.8% and 1.4% respectively. The mean age for the study is 48.1 years, with a standard deviation of 9.3. In total, 4.5% had no formal education, whereas 95.5% of the respondents were educated. The number of household members categories was divided into 1 to 5 persons (56.9%), 6 to 10 persons (42.8%), and above 10 persons (0.3%). Table 2 shows that 78.4% of the respondents had a farm size between 1 hectares to 5 hectares and 19.4% with a farm size between 6 hectares and 10 hectares. The result further reveals that 2.4% have above 10 hectares as their farm size.

Table 2. Farm head and farms‘ characteristics

Variable	Description	Percentage (%)
Gender	**Male**	**83.0**
	Female	17.0
Age	Less than 31	3.8
	31-50	**60.8** (Mean - 48.1)
	51-70	34.4
	Above 70	1.4
Educational level	No formal education	4.5
	Educated	**95.5**
Number of HH members	**1-5**	**56.9**
	6-10	42.8
	Above 10	0.3
Farm size	**0.1-5**	**78.4**
	6-10	19.4
	Above 10	2.4

Source: own calculation

Inputs respondents benefited from the e-wallet scheme

The results in Figure 6 show the various types of agricultural inputs from which the farmers who adopted the e-wallet benefitted. It shows that 48.96% received improved seeds, 45.83%

received NPK fertiliser, 37.15% received urea fertiliser, 6.6% micro-nutrient, and 5.56% improved cassava cuttings.

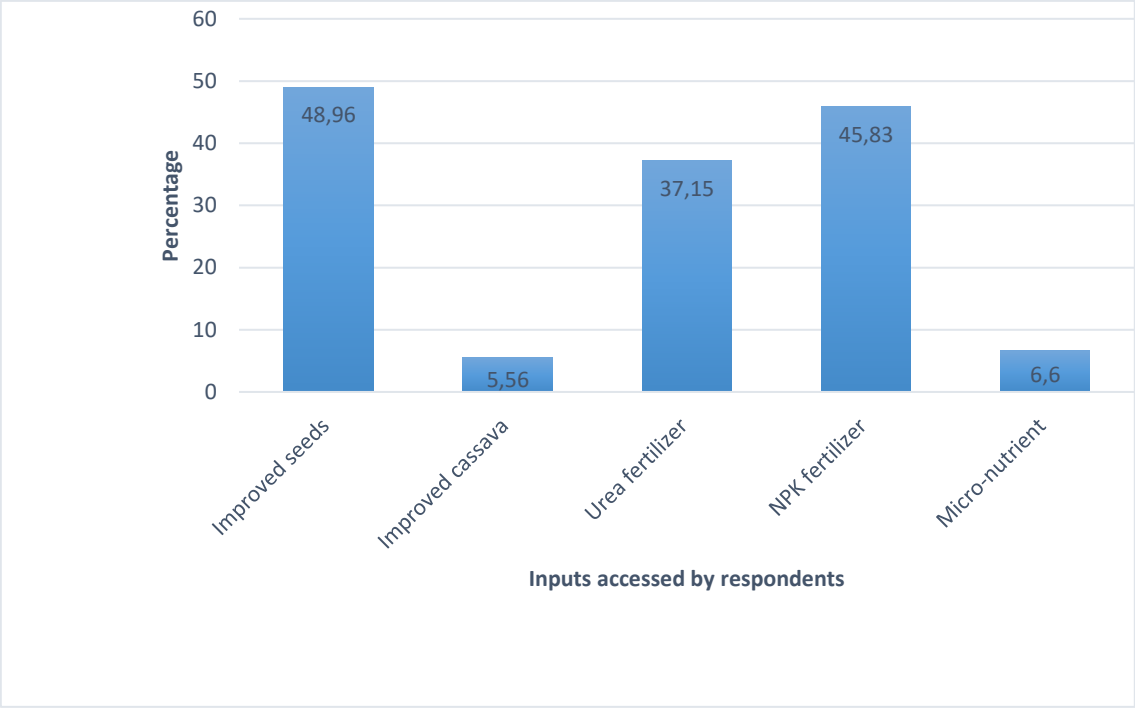

Figure 6. Agricultural inputs benefited by the participant in the e-wallet programme (Source: own calculation)

Sustained use of agricultural inputs received through e-wallet

The results in Figure 7 revealed the distribution of the respondents based on whether they will continue to use the inputs they received through the e-wallet scheme. The results show that 45.84% will continue to use improved seeds, 42.36% urea fertiliser, and 42.01% NPK fertiliser, while 29.52% and 17.72% agreed to sustain the use of improved cassava cuttings and micro-nutrient, respectively.

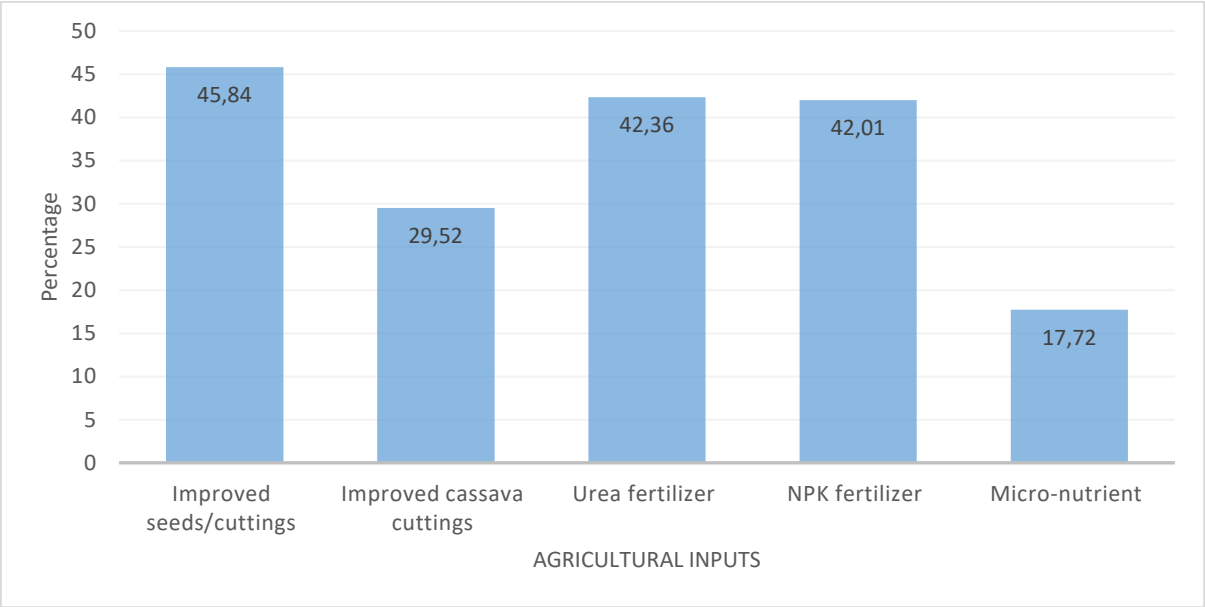

Figure 7. Opinion of the farmers on the sustained use of inputs received through the e-wallet. (Source: own calculation)

Other agricultural programmes farmers adopted

Figure 8 reveals the various agricultural programmes the respondents participated in before introducing the e-wallet. The result shows that 31.94% of the farmers previously participated in Farmers' Field School (FFS), while 19.44% adopted Fadama before introducing the e-wallet.

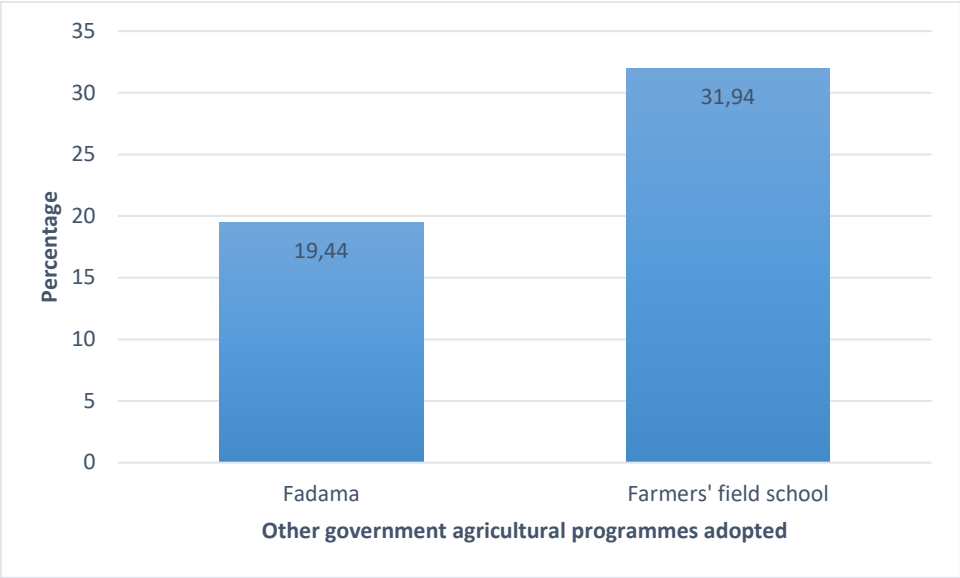

Figure 8. The other government agricultural programs that farmers participated in before the e-wallet (Source: own calculation)

Perception of the e-wallet scheme

Table 3 presents the respondents' perceptions of who participated in e-wallet regarding implementing the e-wallet scheme. The minimum and maximum values were 1 and 5, respectively, based on a Likert scale of strongly disagree, disagree, undecided, agree, and strongly disagree. The result shows the average number (x = 3.69) of the respondents who agreed that the e-wallet scheme had reduced corruption in input supply, with an average of 3.92 as the mean who agreed that the telephone method is very suitable to access input for farmers. However, the respondents also agreed to a large extent that the number of extension agents was not enough, and the sustainability of a government policy like an e-wallet could drop when there is a change of political leadership in the country, with an average of 3.91 and 4.05, respectively.

Table 3. The perception of the respondents that participate in the e-wallet scheme

Variable/Perception	Mean	Std. Dev.	Min	Max
The e-wallet platform has reduced corruption in input supply	3.69	1.049	1	5
For farmers, the telephone method is very suitable for accessing input	3.92	0.930	1	5
Insufficient Extension agents	3.91	0.949	1	5
Inconsistency in government policies has affected the sustainability (success) of the e-wallet scheme	4.05	0.999	1	5

Source: own calculation

6.2 Influence of communication channels on farmers' e-wallet adoption

Logistic regression model variables

The results in Table 4 show the descriptives of the categorical variables included in the logistic regression model (eq. 1). It shows that e-wallet adopters constituted 54.16% of the sample, most (82.64%) were male, and 42.36% had secondary education. On the other hand, only 19% and 31% benefited from the Fadama programme and attended farmers' field school, respectively.

Table 4. Description of logistic regression variables (categorical variables); e-wallet adoption analysis

Variable	Description	Adopters N=155 (%)	Non-adopters N= 133 (%)	Total (%)
Gender	Male	46.88	35.76	82.64
	Female	6.94	10.42	17.36
Education	None	2.78	1.74	4.51
	Adult	3.82	4.86	8.68
	Primary	14.58	11.46	26.04
	Secondary	21.88	20.49	42.36
	Tertiary	10.76	7.64	18.40
Fadama	Participant	13.54	5.90	19.44
	Non-participant	40.28	40.28	80.56
Farmers field school	Participant	21.53	10.42	31.94
	Non-participant	32.29	35.76	68.06

Source: own calculation

Table 5 describes continuous variables included in the logistic regression (2). The result shows that the mean age of the respondents was 48.11 years. The average number of members per household was found to be 5. The average farming experience of the respondents was 16.65 years. The mean land size was 3.82 hectares with a standard deviation of 3.09. The findings show a statistically significant mean difference between the two groups, with the adopters having a less average land size when compared to the non-adopters. There was an average of about four extension contacts per farming season, with a higher mean value reported for adopters than the non-adopters group.

Table 5. Description of logistic regression variables (continues variables); e-wallet adoption analysis

Variable	Description	Adopters (N=155)	Non-adopters (N=133)	P-value	Total (N=288)
Age	Number of years	49.41 (8.9)	46.59 (9.6)	0.235	48.11(9.34)
Household size	Number in the house	5.36 (1.6)	5.17 (1.9)	0.099	5.27 (1.79)
Farming experience	Years of farming	17.32 (9.9)	15.86 (11.0)	0.246	3.35 (1.26)
Land size (ha)	Land under cultivation	3.72 (2.4)	3.94 (3.7)	0.014	3.82 (3.0)
Extension contact	How frequent (1-5)	4.03 (0.8)	3.50 (1.5)	0.000	3.98 (1.5)
Radio	Frequency (1-5)	3.19 (1.2)	3.13 (1.4)	0.171	3.35 (1.4)
Television	Frequency (1-5)	3.00 (1.2)	2.97 (1.2)	0.004	3.18 (1.2)
Internet	Frequency (1-5)	1.92 (1.2)	2.03 (11.4)	0.001	2.01 (1.2)
Cooperative	Frequency (1-5)	3.41 (1.1)	3.29 (1.4)	0.004	3.54 (1.1)
Staff of Fed. Ministry of agriculture	Frequency (1-5)	2.51 (1.1)	2.05 (1.2)	0.982	2.48 (1.2)
Farmers group	Frequency (1-5)	3.86 (1.0)	3.51 (1.5)	0.000	1.97 (1.3)

Source: own calculation. **Note:** Mean values and the standard deviation in parentheses are reported. Info means information

Logistic regression results for the e-wallet adoption analysis

Regarding objective 1, Table 6 presents the findings on the factors associated with adopting the e-wallet.

Household head characteristics

The result in Table 6 shows a significant negative relationship between gender and the adoption of the e-wallet. The result indicated that gender determined whether farmers adopted the e-wallet, which had a significant negative effect of α=0.05. The findings on gender show that female-headed households had a greater chance of participating in the e-wallet programme.

The results also indicate that the age of the farmers had a significant positive relationship with the adoption of the e-wallet. It shows that age contributed to a greater likelihood of farmers adopting the e-wallet with a significant positive effect of α=0.05. Furthermore, the age of the household head revealed a positive impact on the adoption of the e-wallet programme. It showed that an increase in one year of farmer age led to a 1.1 % increase in the likelihood of adopting the e-wallet platform.

Farm characteristics

The result in Table 6 shows a significant negative relationship between farm size and the probability of adopting the e-wallet by farmers with a significance level of α=0.01. A unit increase in land size (per hectare) reduces the probability of farmers participating and adopting the e-wallet.

Influence of information sources and channels used by farmers on the adoption of e-wallet

Table 6 shows a significant positive relationship between the extension contacts' intensity and the e-wallet adoption at a significant positive effect of α=0.05. The result implied that extension contact influenced the adoption of the e-wallet programme. Those with extension contact were more likely to adopt the e-wallet programme. Based on the scheme's structure, the extension agents were involved in creating awareness about the e-wallet and helped to

guide those that had difficulties in registering. The findings in Table 6 also indicate a significant negative relationship between the use of television as a source of agricultural information and the adoption of the e-wallet at a significant negative effect of α=0.05. Farmers who use television as a source of agricultural information were less likely to participate in the e-wallet programme because there are fewer agricultural programmes on television than radio. In addition, there are challenges with the power supply to power the TV sets. Still, radio can be used without a power supply. Table 6 also indicates a significant negative relationship between participation in cooperative society and the propensity to adopt the e-wallet at a significant negative effect of α=0.05. The farmers that participated in a cooperative society showed less likelihood of adopting the e-wallet in the study sample due to the financial services they are receiving from the cooperative society they belong to, which will allow them to buy more inputs than the government is providing. In addition, some cooperatives have an input support scheme for their members, which could make members not use the e-wallet intervention. Table 6 also shows a significant positive relationship between farmers' contact with the Federal Ministry of Agriculture staff and the adoption of the e-wallet at a significant positive effect of α=0.05. Contact with the Federal Ministry of Agricultural staff as an information source increases the farmer's likelihood of participating in the scheme.

Table 6 indicates a negative non-significant relationship between the use of the internet as a source of agricultural information and the adoption of the e-wallet at a significant negative effect of α=0.05. Farmers with access to the internet showed less prospect of participating in the e-wallet programme because the internet was not used as a medium to create awareness about farmers' engagement in the e-wallet, and the internet is used mainly for social interaction. Table 6 shows a significant positive relationship between information usage of farmers within farmers' groups and the adoption of the e-wallet at a significant positive effect of α=0.01. Furthermore, the households with membership in farmers' groups indicated a greater likelihood of participating in the e-wallet programme than households without such membership because agricultural information gets more to farmers in groups than individuals.

Institutional characteristics

Table 6 also shows a significant positive relationship between farmers who participated in the Fadama programme and the probability of adopting the e-wallet at the significance level of α=0.05. The farmers who participated in the Fadama programme were more likely to adopt the e-wallet platform when compared to non-participating farmers. The result shows a non-significant negative relationship between the enrolment of farmers in field schools and the adoption of the e-wallet at a significant positive effect of α=0.05. Enrollment in farmers' field schools, schools without walls, and a group-based adult learning method for teaching farmers to experiment and solve problems independently increase the chances of adopting the e-wallet program. The marginal effect shows that gender, age, extension contact, Federal Ministry of the Agriculture staff, television, television, Fadama and the Farmer Field School were positive and significant at 5%, which indicates that a 1% increase in each of these variables will lead to 0.0005 increase the probability to participate in the e-wallet scheme.

Table 6. Influence of information sources on the adoption of e-wallet

Variable	Marginal Effect	Stan. Error	P-value
Gender	-0.222	0.093	0.018**
Age	0.011	0.005	0.043**
Household size	-0.026	0.024	0.279
Level of education	0.009	0.039	0.818
Farming experience	0.003	0.004	0.418
Farm size	-0.041	0.0148	0.005***
Extension contact	0.106	0.048	0.027**
Fed. Min of Agric staff	0.095	0.037	0.011**
Farmers groups	0.015	0.015	0.000***
Television	-0.086	0.042	0.043**
Cooperative society	-0.010	0.046	0.026**
Radio	-0.031	0.035	0.375
Internet	-0.059	0.031	0.060*
Fadama	0.2104	0.084	0.013**
Farmers Field School	0.1415	0.077	0.067**
LR Chi2 (15)	70.56		
Prob> Chi2	0.0000		
Pseudo R^2	0.1775		

Source: own calculation

Note: Statistical significance at 10 % (*), 5 % (**) and 1 % (***).

Barriers to the adoption of e-wallet

Adopting the e-wallet was affected by several barriers perceived differently by adopters and non-adopters, as shown in Table 7. The result shows a significant difference between the distance to redemption centres, GSM network fluctuation, phone condition, long process, and phone navigation regarding the inability to understand how to access messages of adopters and non-adopters at a significant level of α=0.01.

The distance to the nearest redemption centres plays a major role in guiding the farmer to either adopt the e-wallet input subsidy programme or not, as the cost-benefits will be weighed. Due to the rural infrastructure challenges, the GSM network connectivity plays a significant role in farmers' access and engagement in deciding whether to participate in the e-wallet scheme. Education is essential to farmers' effective use of mobile phones as important information about the e-wallet is transmitted by mobile phones. Farmers with a better understanding of accessing the information on their phones will be more propelled to adopt the e-wallet. Many farmers engaged in the survey still find it challenging to understand how their phone works despite their education. It also shows a significant relationship between the high payment contribution of adopters and non-adopters at a probability level of $p<0.05$. The farmers need to evaluate the logistics cost required to access the e-wallet subsidy and compare it with the price they will get in the open market.

Table 7. Main indicators of e-wallet adoption barriers experienced by adopters and non adopters

Variable	Adopters (n=155) Mean	Non-adopters (n=133) Mean	P-value
Distance to redemption centre	1.86 (1.21)	2.86 (1.48)	0.000***
GSM network fluctuation	2.65 (1.05)	2.83 (1.39)	0.000***
Condition of the phone	2.08 (0.95)	2.20 (1.34)	0.000***
Long process	2.83 (1.07)	2.53 (1.47)	0.000***
Technical support	2.73 (1.28)	2.79 (1.28)	0.782
Phone navigation	2.50 (1.14)	2.59 (1.40)	0.008***
High payment contribution	2.77 (1.12)	2.38 (1.30)	0.021**
Low level of awareness	3.43 (1.269)	3.08 (1.42)	0.101

Source: own calculation

Note: Statistical significance at 5 % (**) and 1 % (***). Figures in parenthesis are standard deviation and significant level of the variables

6.3 Adoption of Sustainable Agricultural Practices

Table 8 shows the description of the variables considered in the six logistic regression models, each relating to one of the SAPs. The results reveal that 185 (62.4%) of the farmers adopted crop diversification, 70 (24.3%) fertiliser trees, 141 (49%) mulching, 121 (42%) animal manure, 67 (23.3%) cover crops, and 27 (9.4%) planting basin. There were 53.8% of the respondents participating in the *e-wallet* programme, 19.4 % of them participated in the *Fadama* project, while 31.9% attended in *Farmers' Field School.* A majority (82.6%) of the respondents were male with a mean age of 48.11 and had on average 16 years of farming experience, with a mean monthly income of 52,656.25 NGN (138.57 USD), with a household mean of five people and a standard deviation of one person, the mean agricultural land under cultivation was 3.82 ha and 43.66% of the respondents owned the land under their cultivation, the average number of yearly extension contact was three times, and the mean yearly meeting participation was 14.67 times.

Table 8. Description of variables in logistic regression model (n = 288)

Variable	Description	Frequency (yes)	(%)
Sustainable Agricultural Practices			
Crop Diversificatio Ddiversification	Farmer adopted practice (yes =1, no =0)	185	64.2
Fertilizer trees	Farmer adopted practice (yes =1, no =0)	70	24.3
Mulching	Farmer adopted practice (yes =1, no =0)	141	49.0
Animal manure	Farmer adopted practice (yes =1, no =0)	121	42.0
Cover crop	Farmer adopted practice (yes =1, no =0)	67	23.3
Planting basin	Farmer adopted practice (yes =1, no =0)	27	9.4
Independent variables			
Policy programme			
E-wallet	Farmer adopted e-wallet (yes =1, no =0)	155	53.8
Fadama	Participate in programme (yes =1, no =0)	56	19.4
Farmer Field school	Participate in programme (yes =1, no =0)	92	31.9
Farmer characteristics			
Gender	Female= 0, Male=1	238	82.6
Age	Number of years	48.11 (9.34)	
Educational level	1= none, 2= adult education, 3= primary, 4= secondary, 5= tertiary	4.5	
Farming experience	Number of years spent in farming	16.65 (10.47)	
Income	Monthly earning	$138.57[1]	
Household characteristics			
Household size	Members of the house	5.27 (1.79)	
Farm Characteristics			
Land size	Land under cultivation (ha)	3.82 (3.09)	
Land ownership (%)	Share of owned land cultivation (ha)	57.78 (43.66)	
Information sources			
Extension contacts	How frequent (1-5)	3.79 (1.23)	
Farmers group	Participate in farmer group meeting	14.67 (4.38)	

Source: own calculation

Note: The numbers in parentheses indicate the standard deviation of the mean value. 1$ =380 Naira.

The results in Table 9 show the influence of agricultural policies, farmers, household, and farm characteristics, including land ownership and institutional factors, on the adoption of the different SAPs considered in the study. Farmers that participated in e-wallet were more likely to adopt fertiliser trees and use animal manure significantly ($p < 0.05$). On the contrary, farmers that participated in e-wallet were less likely to adopt planting basins at the significance level 0.1. Concerning the Fadama policy programme, the finding shows that the farmers who participated in Fadama were less likely to adopt crop diversification $p < 0.01$). Participation in Farmers' Field School (FFS) contributed to a greater likelihood of farmer adopting crop diversification and cover crops at the significance level0.1) and 0.05, respectively. Gender has a significant negative effect on crop diversification, animal manure, and planting basins. The result indicated that female-headed households were less likely to adopt crop diversification and animal manure at the significance level of $\alpha= 0.01$. Similarly, female-headed households are less likely to use planting basins than male¬headed households. We found a positive and significant contribution for age on adopting three of the practices including crop diversification ($\alpha= 0.01$), mulching ($\alpha= 0.05$), and animal manure ($p < 0.01$). The findings show that older farmers were more associated with adopting crop diversification, mulching, and animal manure than younger farmers. The results demonstrate that farmers with more farming experience were less likely to adopt crop diversification, animal manure, cover crops, and planting basins than farmers with less experience, with the significance level of $\alpha=0.01$, $\alpha= 0.01$, $\alpha= 0.01$ and $\alpha= 0.05$, respectively. An increase in income correlates with a lesser likelihood of adoption of planting basins at $\alpha=0.05$.

Household size as a significant negative effect on the adoption of the two practices, mulching (at $\alpha= 0.1$) and animal manure (at $\alpha= 0.01$). Household size exhibits a significant positive effect on the probability of the adoption of cover crops and planting basins. (at $\alpha= 0.01$). Is there any explanation for it? The results (Table 9) revealed that an increase in land size negatively significantly affects the probability of crop diversification adoption and positively affects the adoption of cover crops. Farmers who were landowners were less likely adopters of fertilizer trees. The result in table 9 further showed that adoption of mulching was higher among the farmers that owned land than the non-landowners or those on rented land. The

results indicate that farmers who have more frequent contact with extension services were less likely to adopt crop diversification ($p < 0.01$) and mulching at ($p < 0.1$).

However, the use of fertiliser trees and animal manure showed a positive contribution for farmers with contact to extension services at $p < 0.01$) and $p < 0.01$, respectively. The farmers that belonged to farmers' groups were more likely to adopt crop diversification and animal manure when compared to non-members based on the frequency of information contact. However, a negative relationship was found for the membership in farmers' groups who had access to SAP information in the adoption of fertiliser trees and cover crops because the group usually decides together to accept an innovation or not.

Table 9. Factots influencing agricultural policy programs and land ownership on the adoption of SAP

Variable	Crop diversification	Fertilizer trees	Mulching	Animal manure	Cover crop	Planting basin
Agricultural policy programme						
E-wallet	0.051	0.013**	0.111	0.153**	-0.030	-0.035*
	(0.066)	(0.052)	(0.070)	(0.070)	(0.050)	(0.022)
Fadama	-0.273***	0.029	-0.043	-0.135	-0.078	0.053
	(0.011)	(0.069)	(0.089)	(0.082)	(0.050)	(0.045)
Farmers	0.126*	-0.028	-0.090	0.038	0.268**	-0.006
field school	(0.105)	(0.057)	(0.075)	(0.078)	(0.0690	(0.020)
Farmer characteristics						
Gender	-0.375***	0.008	-0.162	-	-0.087	-0.072*
	(0.087)	(0.068)	(0.098)	0.284***	(0.003)	(0.038)
				(0.104)		
Age	0.130***	-0.003	0.011**	0.022***	-0.0003	0.0006
	(0.004)	(0.003)	(0.005)	(0.005)	(0.003)	(0.001)
Education	-0.010	-0.015	0.066	0.009	0.004	-0.007
level	(0.034)	(0.025)	(0.036)	(0.036)	(0.027)	(0.009)
Farming	-0.015***	-0.000	-0.004	-	-	-0.002**
experience	(0.003)	(0.002)	(0.004)	0.012***	0.012***	(0.001)
				(0.004)	(0.003)	
Income	-5.550	5.580	1.010	-6.060	-2.570	-5.730**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Household characteristic						
Household	0.005	0.015	-0.031*	-	0.061***	0.025***
size	(0.019)	(0.015)	(0.021)	0.284***	(0.016)	(0.007)
				(0.021)		
Farm characteristics						

Land size	-0.053***	0.016	0.019	0.010	0.031***	0.004
	(0.015)	(0.010)	(0.070)	(0.013)	(0.010)	(0.003)
Land ownership	-0.004	-0.002***	0.002***	0.001	-0.001	-0.0002
	(0.008)	(0.000)	(0.000)	(0.080)	(0.007)	(0.0002)
Information sources						
Extension contact	-0.184***	0.083***	-0.080*	0.113***	0.010	0.003
	(0.040)	(0.030)	(0.040)	(0.041)	(0.0270	(0.010)
Farmers group	0.046***	-0.015*	0.004	0.018*	-0.012*	-0.001
	(0.011)	(0.008)	(0.011)	(0.010)	(0.007)	(0.002)
Number of observation	288					
LR chi^2 (13)	86.89	44.11	57.79	75.27	73.08	45.20
Prob >chi^2	0.0000	0.000	0.0000	0.0000	0.0000	0.0000
Pseudo R^2	0.277	0.138	0.145	0.192	0.234	0.252

Source: own calculation
Significance levels ***= p<0.01, **= p< 0.05, *= p<0.1. The numbers in parentheses indicate the standard errors.

7. Discussion

7.1 Household and farm characteristics

Findings on gender show that female-headed households had a greater chance of participating in the e-wallet programmes. This agreed with Donkor et al. (2016), who reported the same result for farmers in Ghana. However, it contradicted the findings of Chibwana et al. (2012), who recorded that male farmers are more likely to participate and get access to subsidized fertilizer coupons in Malawi. The age of the household head revealed a positive impact on the adoption of the e-wallet programme and showed that an increase in one year of farmer age led to a 1.1 % increase in the likelihood of adoption of the e-wallet platform. This finding showed that older farmers were more interested in adopting the e-wallet when compared to younger farmers, probably because most of the older farmers in rural areas were practising subsistence farming in which the small quantity of inputs obtained from the scheme could create an appreciable increase in their production. This was in line with Donkor et al. (2019), who reported a significant impact of age on the likelihood of using chemical fertilizer promoted and distributed by the government among rice farmers in Ghana. These results were also in line with those of Chibwana et al. (2012), who revealed that age had a positive, significant influence on the likelihood of adopting and participating in a subsidized fertilizer coupon programme in Malawi and with those of Chirwa and Dorward (2013), who reported the significant impact of household head age on getting fertilizer coupons in Malawi. However, Uduji et al. (2018) did not find any effect of age. A unit increase in land size (per hectare) reduces the probability of farmers participating and adopting the e-wallet. This can be explained due to the nature of the e-wallet programme, which focused only on smallholder farmers with less than 5 hectares of farmland. The quantity of input (fertilizer, seed, herbicide) distributed was the same for all farmers irrespective of their farm size. These findings were in line with Sani et al. (2018), who reported that smallholder farmers adopted and had access to subsidized fertilizer under the GESS programme more frequently than farmers with large farm sizes in the western agricultural zone Bauchi state, Nigeria.

The results regarding the information sources and communication channels show that extension contacts were a vital means of promoting participation in the e-wallet programme. This is in line with Uduji & Okolo-Obasi (2018) findings that contact with the extension agent increased farmers' involvement in the e-wallet programme in Nigeria. Similarly, Sani et al. (2018) recorded the significant impact of extension contact on participation and access to subsidized fertilizers under the GESS programme among farmers in the western agricultural zone of Bauchi state, Nigeria. This is also in line with Ragasa and Mazunda (2018), who reported a significant influence of extension contact on participation and access to agricultural input subsidies in Malawi. Differently, in a study in Tanzania, extension contacts were reported to prevent the distribution of subsidy vouchers (Pan and Christiaensen 2012). Contact with the Federal Ministry of Agricultural staff as an information source increases the farmer's likelihood of participating in the scheme. This is feasible because the Federal Ministry of Agriculture staff were actively involved in the field supervision of the scheme. The households with the membership of farmers' groups indicated a greater likelihood of participating in the e-wallet programme than households without such membership. The introduction of the e-wallet gave all members of farmers' groups the opportunity to have access to information about e-wallet which enhanced their participation, irrespective of their status in the group with the group deciding together about the adoption of the innovation, compared to the previous subsidy programme where subsidies were distributed at the discretion of government agents without getting to the farmers' group (Liverpool-Tasie 2014a). This is in line with the findings of Aknbile et al. (2014), who investigated the factors affecting the utilization of the e-wallet to access agricultural information in Nigeria and found that membership of farmers' groups influenced e-wallet adoption. Liverpool-Tasie (2014b) also revealed that farmers' group membership is an excellent platform for giving farmers access to various opportunities like more frequent extension visits that motivate their participation. Further, Uduji et al. (2019) affirmed the use of farmers' groups to reach farmers with the needed agricultural information to enhance their participation in agricultural innovation. Farmers that use television as a source of agricultural information were less likely to participate in the e-wallet programme due to the low level of agricultural related TV programs than the radio because more entertainment programs are of high priority to TV viewers and power supply outages to power TV. This is contrary to the

study of Sani et al. (2018). They reported a positive correlation between using television as a source of agricultural information on participation and access to fertilizer under the GESS programme among farmers in the western agricultural zone of Bauchi state, Nigeria. This is because inconsistency in the electricity supply and farmers access more agricultural information on radio than TV are key to the variation in the dichotomy of the findings. The farmers that participated in a cooperative society showed less likelihood of adopting the e-wallet in the study sample. One explanation for this result may be that e-wallet participation was not embraced a group because group discissions matter a lot in cooperatives and there are provisions to support farmers with inputs Furthermore, a cooperative society contributes money to buy goods and sell while the profit is shared as dividends among the members. Nigeria farmers have been explained to operate at a small scale and are concentrated in rural areas. The farmers may prefer to save their money in the cooperative group, which will yield dividends to buy more farm inputs instead of the limited inputs received from e-wallet. Farmers with access to the internet showed less prospect of participating in the e-wallet programme. One reason could be that primarily the internet is not seen as a platform to access agricultural information but as a platform to socialize.

The farmers who participated in the Fadama programme were more likely to adopt the e-wallet platform when compared to non-participating farmers, which confirmed the influence of previous government programmes in influencing the adoption of innovation and that Fadama was seen as an influential group to disseminate information. Coker (2014) confirmed the importance of the World Bank assisted Fadama-III programme in aligning with the e-wallet scheme. Enrollment in Farmers' Field Schools, schools without walls, a group-based adult learning method for teaching farmers to access helpful information, experiment, and solve problems independently increases the chances of adopting the e-wallet program because they access the required information that allays their fears and encourages them to adopt e-wallet.

The adoption and non-adoption of the e-wallet were affected by several barriers perceived differently by adopters and non-adopters, as shown in Table 8. As expected, the distance to redemption centres was higher for non-adopters. The finding of the increased importance of

the distance to the redemption centre in the sample is in line with Uduji et al. (2018), who revealed that distance to redemption centres negatively affected the adoption of the e-wallet among smallholder farmers in Nigeria. The redemption centre's location is essential as the cost of getting to the redemption centres was sometimes higher than the benefit from the subsidy (FESPAN 2012). Collier and Dercon (2014) also noted that low-income farmers were prevented from accessing agricultural opportunities that would enhance their production due to distances and the high cost of transportation. The sample revealed that GSM network fluctuation was a significant barrier for non-adopters participating in the e-wallet programme. Poor infrastructure in some rural areas limits the coverage of the network service. This agrees with Nwaobiala and Ubor (2016), who found that poor network coverage was a challenge encountered by smallholder farmers in Nigeria. Phone users in urban and rural areas in Nigeria usually experience intermittent and weak broadband signals due to the poor infrastructural development of the telecommunication industry (Nwalieji et al. 2015). Also, Uduji et al. (2018) found that mobile network coverage facilitates the adoption of the e-wallet in Nigeria. Network coverage and dominance are vital for mobile services and accounted for 40 % when selecting mobile money solutions in Kenya. Further, the users perceived network dependability at 27 % in choosing mobile money solutions (Mwangi & Brown 2015). In Ghana, the adoption of public e-procurement was negatively affected by poor internet connectivity and slow network speeds among the respondents (Adjei-Bamfo et al. 2020). Pal et al. (2020) indicated the effects of the risk of failure in transactions on the adoption of mobile payment services in India however, mobile money services contributed to the empowerment and enhancement of the users with multiple opportunities for socio-economic development. The condition of the phone was another challenge to the adoption of an IT-based e-wallet programme by smallholder farmers. Further, some farmers found it difficult to know when a text message arrived and how to use phone keypads to reply to messages sent from the redemption centre. Though many smallholder farmers were struggling below the poverty line, their 50 per cent payment contribution was still regarded as unaffordable when combined with the stress of accessing the redemption centres. This barrier was also identified by Asfaw et al. (2017), who discovered that some farmers in Malawi could not redeem their vouchers due to financial constraints.

7.2 Adoption of Sustainable Agricultural Practices

Farmers that participated in e-wallet were more likely to adopt fertiliser trees and use animal manure. The explanation may be insufficient quantity of fertilizer provided through the subsidy to cover the entire farmland and farmers have to resolve into other means of fertilizing their farm, which are the use of fertilizer trees and animal manure. The e-wallet subsidy provided a 50 % discount on only two 50-kg bags of fertilizer (NPK and urea) per farmer (Wossen et al. 2017). However, the e-wallet scheme could not fully meet the fertilizer demands of the farmers due to the small quantity provided and sometimes late arrival of inputs and long-distance to dealers outlet, which accrued high cost of transportation.. Thus, farmers had to use fertilizer trees and organic fertilizer as alternatives to mineral fertilizers (Agbarevo & Ukagha 2018). The results further showed that farmers that did not participate in e-wallet were less likely to adopt planting basins. The possible reason for that is that e-wallet was targeted towards fertilizer application, and there is a high probability of fertilizer waste when practising planting basin, and again, the e-wallet beneficiaries have little fertilizer to manage based on the restricted subsidy received. Concerning the Fadama policy programme, the finding shows that the farmers who participated in Fadama were less likely to adopt crop diversification. This may happen because the farmer has very few alternatives in the study area, as not all crops can thrive in this area because of the way the Fadama program works and the terrain. Further, the programme promoted crop intensification to meet food demand in the country, which promoted mechanization that does not conform to cultivating different crops. However, the case is different in the case of Southern Guinea Savannah of Nigeria. Lawal et al. (2010) confirmed that the *Fadama* farming household involved in food crop production in Southern Guinea Savanna of Nigeria adopted various crop diversification strategies to fully maximize the use of the area under *Fadama,* which may be attributed to the effect of different ecological zones, as the study area has mainly tropical forest agroecology.

Participation in Farmers' Field School (FFS) contributed to a greater likelihood of farmer adoption of crop diversification and cover crops. This was an expected result as the field schools concentrated on promoting practices such as crop diversification and changing

planting dates (Adger et al. 2003; Bradshaw et al. 2004). Our finding confirmed that by Tomlinson and Rhiney (2018), farmers in Jamaica that were involved in *FFS* adopted cover crops and crop diversification more than non-participants. The finding that most farmers who adopted cover crops attended *FFS* is also in line with Pratt and Wingenbach (2016) results in Paraguay.

Regarding gender, the result indicated that female-headed households were less likely to adopt crop diversification, animal manure, and planting basins than male-headed households. This can be confirmed by Raufu and Adetunji (2012) when looking at the determinant of land management practices among crop farmers in Osun State, Nigeria, where male farmers dominated crop diversification and other SAP. Usman et al. (2016) confirmed that the use of animal manure was dominated by the male arable crop farmers in Taraba State, Nigeria, which could be due to the socio-cultural background of the people and how intensively labour demanding land management practices could be. On the contrary, Ndiritu et al. (2014) indicated that male-headed households were less likely to adopt animal manure in Kenya. However, Hove and Gwene (2018) also revealed that smallholder farmers, especially women farmers in Zimbabwe, confirmed that the task was demanding and the farmers who were interested in benefiting from planting basins opted for the creation of groups for teamwork and rotated among members farms in the preparation of planting basins.

Concerning age, the sample findings show that older farmers were more associated with adopting crop diversification, mulching and animal manure. Similarly, Agboola (2016) ascertained that older farmers showed more technical efficiency in mulching, crop diversification, and the use of animal manure than the younger farmers in Northcentral Nigeria. The results demonstrate that farmers with more farming experience were less likely to adopt crop diversification, animal manure, cover crops, and planting basins, which unexpectedly partly contradicts the finding of age effects which could be because they prefer to try our modern techniques and probably tired of the old practices they are used to. The possible reason is associated with not being willing to divert from older practices with which they are more comfortable. This raises concerns about providing enough information and visible demonstrations of the benefits for more experienced farmers to adopt some practices.

Regarding crop diversification, our finding is in line with Makate et al. (2016) who found that farmers with more years of farming experience did not adopt crop diversification compared to the farmers with less farming experience in Zimbabwe. Edmundo et al. (2002) argued further that the knowledge gained by the farmers over the years in interacting with the soil gives them more advantages in adopting SAP. An increase in income correlates with a lesser likelihood of the adoption of planting basins. This is because planting basins are small-scale technology in nature, therefore, the increase in a farmer's income leads to an interest in other forms of cultivation that is not time-consuming and will lead to increased yield. The cultivation practices in the study area is more focused on crop diversification, animal manure use and mulching.

An increase in household size is associated with a lesser likelihood of adopting mulching and animal manure practices. This is in line with the findings of Amao et al. (2013) in Osun State in Nigeria, who found that, despite large household sizes, which reflect the high proportion of children that constitute household labour, children could not effectively and efficiently carry out all farm operations. On the other hand, an increase in the number of people in a household led to a greater likelihood of adopting cover crop and planting basin practices. This is not surprising concerning the adoption of planting basins by larger households due to its labour sensitivity. Muhammad-Lawal (2014) revealed that a large household size among small scale food crop farmers in Kwara State, Nigeria, enhances land management practices due to the availability of more labour.

The results revealed that an increase in land size reduces the probability of adoption of crop diversification. The possible reason is that most of the farmers with large farm size practice monocropping as being more compatible with mechanization and likely to be more profitable in line with the economics of scale in commercial agriculture. This confirms Kasem and Thapa (2011) who found that farmers mainly practised crop diversification with smaller land sizes in Thailand. However, a more extensive land size indicated a greater likelihood of adopting crop covers. Farmers who were landowners were less likely adopters of fertiliser trees. Our results further showed that the probability of adopting mulching was higher among the farmers who owned land than the non-landowners or those on rented land because

landowners have more control over their land management practices. As regards fertilizer trees, the possible reasons for this are that landowner farmers might like to maximize the use of their space as soon as possible without considering long-run effects, or they are not interested in the long term, and large investments such as fertilizer trees, or they may simply lack the capital needed. Muhammad-Lawal et al. (2014) reported that the transferability of property rights in Nigeria negatively affects the adoption of long-term SAPs because there is no certainty that the person who earns the property right will be interested in SAP especially when it's a long-term investment. Similar to our study, Deininger's (2003) results showed a negative relationship between farm size and some land management practices such as tree planting, including fertilizer trees. Our results further showed that the adoption of mulching was higher among the farmers that owned land than the non-landowners or those on rented land. Owombo and Idumah (2015) also found, when determining land conservation technology adoption among arable crop farmers in Nigeria, that 56.6% of the mulching adopters, 59.4 % of the cover cropping adopters and 73.4% of the tree planting adopters owned the plots on which they operated.

A review on the adoption of SAPs by Baumgart-Getz et al. (2012) considered access to and quality of information and local networks of farmers as the variables with the most significant contribution to adopting sustainable practices. The agricultural policies facilitate the adoption of sustainable practices, which can be necessitated by boosting information channels and extension services (Cao et al. 2020). Unexpectedly, our results indicate that farmers who have more frequent contact with extension services were less likely to adopt crop diversification, mulching, and animal manure. The reason for this can be the type of SAP practices introduced to farmers and the mode of disseminating the SAP information. Further, anecdotal evidence says that farmers expect monetary incentives to implement new practices, which the government does not provide. However, other studies demonstrate a positive relationship between extension services and the adoption of SAP in Nigeria (Okunade 2006; Owombo & Idumah 2015). Concerning crop diversification, our finding contrasts with McCord et al. (2015), who found that farmers with access to extension contacts adopted greater crop diversification than those without access in Kenya. Our study is consistent with Wondimagegn et al. 2011), where extension contacts did not influence the adoption of crop

diversification in Ethiopia which could be due to the focus of extension services on farmers' productivity and profitability with emphasis on micro-level of cultivation over crop diversification as a risk minimization measure. However, our study indicates that the use of fertilizer trees that are also readily available was more likely to be adopted by farmers with contact to extension services, as extension services disseminate necessary information about different agricultural practices to the farmers. Contact with extension services is a channel for the provision of information and the farmers' exposure to the management of fertilizer trees. In support of this, Coulibaly et al. (2017) indicated that knowledge attained through training provides farmers with capabilities and skills to manage agroforestry in Malawi efficiently. The farmers that belonged to farmers' groups were more likely to adopt crop diversification and animal manure, which could be related to the group's common interest. At the same time, a lesser likelihood was observed in the adoption of fertilizer trees and cover crops which could be due to the type of common crops grown by the group and the common agricultural management practices generally accepted by the group. Materechera (2010) found similar results regarding animal manure, who indicated that training provided technical information for farmers, resulting in more farmers adopting animal manure usage in South Africa.

The study reveals that extension contact influenced farmers to participate in the e-wallet programme regarding the first question. The result implied that farmers with more extension contact were more likely to adopt the e-wallet programme. Because of the knowledge that the extension agent will share will affect the farmers' adoption level of the e-wallet. Regarding the second question, the result shows a significant relationship between the distance to redemption centres, GSM network fluctuation, Condition of the phone, long process and phone navigation are the major technical barriers to the adoption of e-wallet in the study area and increasing mobile phone services in rural Nigeria enhances farmers' knowledge, information and adoption of improved farm inputs and by extension, spurs rural informal sector economic activities. The third question revealed that the farmers adopted SAP through crop diversification, 70 (24.3%) fertilizer trees, 141 (49%) mulching, 121 (42%) animal manure, 67 (23.3%) cover crops, and 27 (9.4%) planting basin. The results also revealed that 53.8% of the respondents used the e-wallet programme, 19.4% participated in

the Fadama project, and 31.9% participated in Farmers' Field School. A majority (82.6%) of the respondents were male with a mean age of 48.11 and had, on average, 16 years of farming experience. With a mean monthly income of 52,656.25 NGN (138.57 USD), with a household mean of five people and a standard deviation of one person, the mean agricultural land under cultivation was 3.82 ha. A 43.66% of the respondents owned the land under their cultivation, the mean yearly extension contact was three times, and the mean annual meeting participation was 14.67 times.

7.3 Findings on research hypotheses

Hypothesis 1: states that information sources and channels used by farmers influence their adoption of the e-wallet; the respondents also had extension contacts and attended farmers' group meetings about two times on average each year, through which they disseminated information while adopters attended the meetings more often than non-adopters. Therefore, our findings support the hypothesis.

Hypothesis 2: states that the technical barriers to the adoption of the e-wallet based on the farmers' perception and the communication channels used has an effect on the use of e-wallets; the distance to redemption centres was higher for non-adopters. That distance to redemption centres negatively affected the adoption of the e-wallet among smallholder farmers in Nigeria. Furthermore, the sample revealed that GSM network fluctuation was a significant barrier for non-adopters participating in the e-wallet programme. In addition, poor infrastructure in some rural areas limits the network service coverage. Therefore, our findings support the hypothesis.

Hypothesis 3: State that Government policy programmes that include e-wallets positively contribute to the adoption of sustainable agricultural practice. Farmers who participated in the e-wallet were more likely to adopt fertilizer trees and use animal manure. Therefore, it supports the hypothesis

8. Conclusions

This study focuses on two main objectives: first, to examine the factors that affect the adoption of the e-wallet among smallholder farmers in Nigeria. Second, the study examined the influence of governmental agricultural programs and land ownership on the use of SAP. The first objective was selected as a higher adoption rate of the e-wallet scheme, and greater use of subsidized inputs would help increase the productivity of smallholder farmers and thus food security. To better understand the adoption process, the two primary purposes were to investigate how the use of information sources affected the e-wallet adoption and to examine the barriers to the adoption of the e-wallet. The results showed that extension contact is essential for the decision on the participation of farmers in the e-wallet programme. This stresses the need to continue building the capacity of the extension system to consistently play the role of an effective information channel to farmers, including information on IT use. Furthermore, the use of extension agents of the various Ministries of Agriculture encouraged the use of subsidized inputs. The result also revealed that farmers who were members of farmers' groups had a higher probability of participating in the support system than farmers who did not belong to any farmers' group. This showed the importance of strengthening the capacity of farmers' groups in supporting farmers to learn about and adopt new policy measures and IT-based innovations.

Regarding the participation of farmers in previous governmental agricultural programmes, it was identified that a farmer's participation in the Fadama programme and Farmers' Field School enhanced the probability of participation in the e-wallet scheme. This showed that the "active" farmers regularly used the opportunities provided by the government, and there was a need also to involve those farmers who did not have much experience in using governmental agricultural programmes. Regarding the perceived behavioural controls (barriers to the adoption), the results showed a problem of low awareness of the e-wallet among smallholder farmers. Further, distances to the redemption centres were one of the major obstacles to the e-wallet scheme. Creating more redemption centres for the e-wallet programmes is a vital approach to overcoming this significant constraint. Regarding IT

connection barriers, it was revealed that GSM network fluctuation was significant. To safeguard the possibility of access to the subsidized inputs for all farmers, there is a need to improve telecommunication connectivity and ensure that local communities are not neglected. In accordance with the Technology Acceptance Model that states that the perceived ease of use of innovation affects the adoption of it, and the inability of the farmer to understand how to access information on their phones was identified as another challenge to the effective participation of the farmers in the e-wallet scheme. There is a need to provide primary education about phone usage for farmers to increase e-wallet acceptance among smallholder farmers. Our research is relevant for both academics and practitioners in IT for development. It shows that to exploit the full potential of IT for improving the economic situation of smallholder farmers, their IT knowledge gaps and several technical barriers, including poor network infrastructure, need to be overcome. This empirical study would help policymakers and development workers to identify conditions of farmer participation in the scheme and design effective measures to increase that participation. The study investigated the factors influencing the adoption of an e-wallet and the barriers to its adoption in southwest Nigeria. Therefore, the results cannot be fully generalized to another part of Nigeria or another place in the world due to differences in political and social settings. Furthermore, although careful efforts were made in the data collection procedures, a particular self-reporting bias cannot be eliminated.

The second objective of this study was motivated by the fact that many countries use agricultural policies to boost agricultural productivity without looking at the effect of such policies on environmental sustainability. To investigate this, we studied the effect of governmental agricultural programmes, including the e-wallet, Fadama and Farmers' Field School, and land ownership on adopting SAPs. The finding shows that government agricultural programmes have a statistically significant effect on adopting several SAPs in various ways.

The main objective of the e-wallet technology of the GESS programme was the support of input and thus intensification of crop production. The results of this study show that the adoption of the programme influences the adoption of fertilizer trees and animal manure in a

positive way. This implies that input support programmes can promote the use of some agricultural inputs that have the same effect on agricultural production. For example, fertilizer trees and animal manure serve the same purpose and are a substitute or complementary to chemical fertilizer. Therefore, agricultural input programmes can be used to help farmers realize the importance of some SAP available in their area. On the other hand, the Fadama programme, which is oriented towards increasing the productivity of small-scale farmers, was found to have a negative effect on the adoption of crop diversification. Thus, it seems that the objective of boosting productivity conflicted with the use of crop diversification by smallholder farmers. This may be explained that crop diversification does not always support the use of farm mechanization. However, more research would be needed to explain this effect.

The Farmers' Field School (*FFS*) programme is oriented toward farmer education, including the area of integrated crop management and its environmental effects. It was found that this programme successfully promoted the adoption of crop diversification and cover crops among the beneficiaries. Land ownership, the result of the land use policy, was found to have a significant positive effect on the adoption of mulching. However, surprisingly, land ownership does not affect the adoption of fertilizer trees. Most landowners and non-landowner farmers in the area see this as capital intensive and are not patient enough to wait for the long-term effects of this investment. This indicated the need for awareness of the benefits and importance of such a long-time investment in agricultural production. Further, the use of extension services was found to have a negative effect on the adoption of several SAPs. Therefore, improved quality of extension services and promotion programmes that encourage farmers to adopt SAPs, especially the adoption of crop diversification, mulching and animal manure due to the low-cost characteristics of their adoption, could be beneficial in the improvement of soil quality and the reduction of production risk. This explorative study identified the effects of the existing policies on adopting the six considered SAPs. Some of these effects are unintended as the policies do not aim to achieve them. Further policy impact studies are needed to understand the effect of various policies that aim at the intensification and increasing productivity of smallholder farming on the adoption of SAPs.

Because of the time and resources available for the research, the study was limited to Nigeria's southwestern geopolitical zone, therefore broad generalisations should be avoided. This study can serve as a solid starting point for future research in Nigeria's other geopolitical zones, which have diverse weather patterns and agronomic methods.

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Appendix

Appendix 1: Questionnaire used for data collection

Social change, agricultural Development Paradigm: The case of E-Wallet utilization amongst farmers in southwestern part of Nigeria

Tick appropriately E-wallet user _____ Non e-wallet user _____

Section A: Social Economic Characteristics

1. What is your age (in years)……..
2. What is your religion? (a) Christianity ( ) (b) Islam ( ) (c) Traditional ( )
3. What is your marital status?
   (a) Single ( ) (b) married ( ) (c) widowed ( ) (d) divorced ( ) (e) separated ( )
4.

In your household, how many are;	**Male**	**Female**
Aged below 5 years		
Aged between 5-17 years		
Aged between 18-59 years		
Aged above 60 years		

5. Household head (a) Male [ ] (b) Female [ ]
6. Educational level (a) No formal education [ ] (b) Adult education [ ] (c) Primary education [ ] (d) Secondary education [ ] (e) Tertiary education [ ].
7. How many % of your household income in 2017 came from the following activities? (total be 100 %)
   (a) Farming _____ (b) Off farm _____ (c) Remitances _____ (d) Others _____

8. Which of these social statuses are you effectively occupying presently? (a) Chief ( ) (b) Religious head ( ) (c) Market head ( ) (d) agric focal leader ( ) (e) agric association member ( )
9. Your estimated household monthly income =N=…….....

10. How long have you been farming? _____ years
11. Your total farm size _____

12. Average size of landholding cultivated (Fill where applicable).

a. Owned _____(ha)

b. Rented _____(ha)

c. Shared _____(ha)

d. Leased _____ (ha)

13. How did you acquire your land? (State the corresponding size) (The total of the options must be the total of the options in question 12)

a. Inheritance _____ (ha)

b. Purchased _____ (ha)

14. Which of the following activities did you perform to raise more income?

Activities	**Absolutely Essential**	**Very Important**	**Of Average Importance**	**Of Little Importance**	**Not Important At All**
Selling labor					
Petty trading					

Employment/job					
Artisanship					
Transport business					
Collecting herbal products					
Others					

15. **Which of these practises, if any, have you adopted in your farming?**

Practices	**Tick appropriate box**
Crop diversification	
Inter-cropping	
Fertilizer trees	
Green manures	
Mulching	
Animal manures	
Cover crop	
Planting basins	

Assess the effect of the e-wallet distribution on food production and the use of inputs

16. What was your crop cultivation area and yield in 2017?

S/N	Crop	Size in ha	Average Production (number of 50kg bags harvested)	Average Revenue (₦)

17. Did you register for the e-wallet programme?

(a) Yes { } (b) No { }

18. Did you participate in the e-wallet programme?

(a) Yes { } (b) No { }

19. What did you benefit through e wallet?

Inputs	Yes	No	If Yes, how many % subsidy?
Improved seeds/cuttings (excluding Cassava)			
Improved cassava cuttings (Free)			
Urea Fertilizer (Subsidized)			
NPK Fertilizer (Subsidized)			
Micro-Nutrient (Subsidized)			
Oil Palm Seedlings			
Fingerlings			

20. How many times did you receive support through the e-wallet platform?

(a) One time { } (b) 2 { } (c) 3 { } (d) 4 { } (e) Others (Specify) _____

21. Are you able to get all the agricultural inputs from your GES redemption centre?

	Yes	**No**	**If No, why?**
On time			
Adequate quantity			

22. . Are you going to keep sustaining the use of the following inputs even if GES ends?

Inputs	Yes	No
Improved seeds/cuttings (excluding Cassava)		
Improved cassava cuttings (Free)		
Urea Fertilizer (Subsidized)		
NPK Fertilizer (Subsidized)		
Micro- Nutrient (Subsidized)		

Examine the effects of communication practices on the adoption of the e-wallet

23. How often do you use the following agricultural information sources?

Source	**Very often**	**Often**	**Sometimes**	**Rarely**	**Not at all**
Extension agents					
Television					

Farmers meeting					
Newspaper					
Cooperative societies					
farmer's association					
Federal Ministry of Agric staffs					
Other farmers					
Radio					
Internet					
Mobile Phone					
Agro dealers					
NGOs					

24. Are you aware of the e-wallet platform of GESS?

25. Do you have access to the internet? (a) Yes { } (b) No { }

26. From which of the government programs did you benefit?

Govt. Program	**Yes**	**No**
Fadama		
Farmers Field School		
Farmers Business School		
National, Special Programme on Food Security (NSPFS)		

Root And Tuber Expansion Programme (RTEP)		
Others		

27. How often do you receive SMS updates during each redemption period?
    (a) Once { } (b) 2-3 times { } (c) 4- 5 times { } (d) More than 5 times { } (e) Not at all { }

28. What's the e-wallet general SMS/Text delivery rate in a year?

    (a) Weekly { } (b) Monthly { } (c) Yearly { } (d) Each farming season { }

29. Who trained you about the e-wallet? (a) GESS officials (b) Extension Agents (c) Agro dealers (d) Nobody

30. What's the frequency of the training? (a) Very often (b) Often (c) Rarely (d) Very few (e) No training

31. When was the training? a. before enrolling b. after enrolling c. Before and after enrolling (d) No training

32. Did you have a good understanding of what you were taught?

    (a) Very satisfactory { } (b) satisfactory (c) partially { } (d) a little bit { } (e) not at all { } (f) No training

33. What was your date of e wallet registration? (a) 2011 { } (b) 2012 { } (c) 2013 { } (d) 2014
    (e) 2015

34. Did you have any reason to update your phone details with the platform? (a) Yes { } (b) No need{ }

35. If 36. yes, why (a) Loss of SIM (b) Network issues (c) Others _____
(d) No need{ }

36. How often do you experience visits from e-wallet officials after redemption? (a) Very Often { }
(b) Often { } (c) Rarely { } (d) Very few { } (e) Not at all { }

37. Did the e wallet platform give you the opportunity to make enquires directly from your phone?
(a) Yes { } (b) No { }

38. If yes, did you receive any feedback when you used the mobile phone feedback platform?
(a) Yes { } (b) No { }

39. Which other communication method would you have preferred in accessing information as regards
the e-wallet platform? (Please explain)

_____

_____

_____

Examine the likely barriers to the adoption of the e-wallet by farmers (users and none users)

40. How do the following affect your participation and access to the e-wallet scheme?

S/N	Statements	Not at all	Little	Somewhat	Much	Very Much
	Gender inequality					
	The distance to the redemption centre					
	I don't have credit/funds					
	The GSM network fluctuates					
	The condition of my phone					
	The process is too long					

	Too many middlemen					
	My level of education					
	Lack of technical support					
	I find it difficult to navigate/use my phone					
	My payment contribution is high					
	Low level of awareness and information about the scheme					
	Access to land					
	Inaccessible loan facilities					
	Inadequate farm machinery					

43. What are your opinions toward the e-wallet components of the GES? **(Users)**

SA- Strongly Agree * A- Agree *U- Undecided * D- Disagree *SD- Strongly Disagree

Statements	**SA**	**A**	**U**	**D**	**SD**
GES's e-wallet platform has reduced corruption in input supply					
e-wallet platform will end up in failure as past programme					
My fellow farmers don't believe in the scheme					
The telephone method is very suitable for accessing input for farmers					
The use of phone codes without internet is suitable for rural farmers					

The input needs of the farmers are met without much stress					
Success will be achieved in developing agriculture if the e-wallet is sustained					
GES could be more improved if farmers were carried along in the planning					
Poor feedback opportunity makes the e-wallet platform uninteresting to me.					
E-wallet has instilled farmers' interest in further agricultural programmes.					
The e-wallet will last long with more commitment from Cellulants and ADP staff.					
Insufficient Extension agents					
The scheme favours the influential farmers more than other farmers					
Change in government has affected the sustainability (success) of the GES program					
The e-wallet platform should be more interactive					
More training would have been given to farmers to make the process easier					

44. What general advice do you have for a better implementation of the e-wallet platform to be more beneficial to small-holder farmers?